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
March 15, 2009
San Antonio Marriott Rivercenter
San Antonio, Texas

Our next meeting will be held on Sunday, March 15, 2009 from 2:00 p.m. to 5:00 p.m. in Suite 1952 of the San Antonio Marriott Rivercenter.

A proposed agenda is attached.

Copy to: Robbie Hall
Daniel W. Falconer, ACI Technical Director
AGENDA
ACI/CRSI COMMITTEE 315 - DETAILS OF CONCRETE REINFORCEMENT

March 15, 2009

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

2. Approval of minutes of last meeting, November 2, 2008, distributed January 27, 2009

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

4. ACI/CRSI 315 Standard
   a. Continue discussion of 315 Standard's future: submission of revisions to ACI 318, 301, and 117. See Exhibits 2 (ACI 301-05, Section 3) and Exhibit 3 (ACI 117-06, Sections 2.1 and 2.2)
   b. Task Group report: outline of new 315 document (Hall, Hetherington, Hunter, Sebastian)
   c. Reapproval of ACI 315-99


   Secretary's Note: Subcommittee B is scheduled to meet on Sunday, March 15, 2009 from 8:30 a.m. to 11:30 a.m. in Suite 618 of the Marriott Rivercenter.


8. New business
ACI/CRSI COMMITTEE 315 ROSTER
March 2009

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Specifications for Structural Concrete
An ACI Standard
Reported by ACI Committee 301

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Chair

Colin L. Lobo
Secretary

Jon B. Ardahl

Marwan A. Daye

Clifford Gordon

David K. Maxwell

Domíngo J. Carreira

Mario R. Díaz

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NOTES TO SPECIFIER
This specification is incorporated by reference in the project specifications using the wording in P3 of the preface and including the information from the mandatory, optional, and submittal checklists following the specification.

PREFACE
P1. ACI Specification 301 is intended to be used by reference or incorporation in its entirety in the Project Specification. Do not copy individual Parts, Sections, Articles, or Paragraphs into the Project Specification, because taking them out of context may change their meaning.

P2. If Sections or Parts of ACI Specification 301 are copied into the Project Specification or any other document,
slabs, and in-place structural members until concrete has reached $f'_c$, in accordance with 2.3.4. If a lower compressive strength is proposed for removal of formwork and shoring, submit detailed plans for review and acceptance. When shores and other vertical supports are arranged to allow the form-facing material to be removed without loosening or disturbing the shores and supports, the facing material may be removed at an earlier age unless otherwise specified.

2.3.2.6 Construct formwork to permit easy removal.

2.3 Reshoring and backshoring

2.3.3.1.1 Submit data for reshoring and backshoring operations shall comply with 2.1.2.1.e and 2.1.2.2.b.

2.3.3.2 During reshoring and backshoring, do not allow concrete in beam, slab, column, or any structural member to be loaded with combined dead and construction loads in excess of the loads permitted by the Architect/Engineer for the concrete compressive strength at the time of reshoring and backshoring.

2.3.3.3 Place shores and backshores in sequence with stripping operations.

2.3.3.4 Tighten shores and backshores to carry the required loads without over stressing the concrete members. Leave them in place until tests required by 2.3.4 indicate that the concrete compressive strength has attained the minimum value specified in 2.3.2.5.

2.3.3.5 For floors supporting shores under newly placed concrete, either leave the original supporting shores in place, or install shores or backshores. The shoring system and the supporting slabs shall resist the anticipated loads. Locate shores and backshores directly under a shore position or as indicated on formwork shop drawings.

2.3.3.6 In multistory buildings, place reshoring or backshoring over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads such that the design loads of the floors supporting the shores, shores or backshores are not exceeded.

2.3.4 Strength of concrete required for removal of formwork

2.3.4.1 When removal of formwork or reshoring is based on concrete reaching a specified compressive strength, concrete will be presumed to have reached this strength when test cylinders, field cured the same as the concrete they represent, have reached the compressive strength specified for removal of formwork or reshoring. Mold cylinders in accordance with ASTM C 31/C 31M, and cure them under the same conditions for moisture and temperature as used for the concrete they represent. Test cylinders in accordance with ASTM C 39/C 39M.

2.3.4.2 Alternatively, when specified or permitted, use methods in 2.3.4.2.b through 2.3.4.2.d to evaluate concrete strength for formwork removal. Before using methods in 2.3.4.2.b through 2.3.4.2.d, submit data using project materials to demonstrate correlation of measurements on the structure with the compressive strength of laboratory-cured molded cylinders or drilled cores. Submit correlation data on the proposed alternative method for determining strength to the Architect/Engineer.

2.3.4.2.a Tests of cast-in-place cylinders in accordance with ASTM C 873. This is limited to slabs with concrete depths from 5 to 12 in.

2.3.4.2.b Penetration resistance in accordance with ASTM C 803/C 803M.

2.3.4.2.c Pullout strength in accordance with ASTM C 900.

2.3.4.2.d Maturity method in accordance with ASTM C 1074.

2.3.5 Field quality control

2.3.5.1 Establish and maintain survey controls and benchmarks in an undisturbed condition until final completion and acceptance of the project.

2.3.5.2 Variations from plumb and designated building lines shall not exceed the tolerances specified in ACI 117.

SECTION 3—REINFORCEMENT AND REINFORCEMENT SUPPORTS

3.1—General

This section covers materials, fabrication, placement, and tolerances of reinforcement and reinforcement accessories.

3.1.1 Submit data, drawings—Unless otherwise required by Contract Documents, submit data and drawings specified in 3.1.1.1 through 3.1.1.3 for review and acceptance before fabrication and execution:

3.1.1.1 Submit the data specified in 3.1.1.1.a through 3.1.1.1.g unless otherwise specified:

3.1.1.1.a Reinforcement—Submit manufacturer's certified test report.

3.1.1.1.b Placing drawings—Submit placing drawings showing fabrication dimensions and placement locations of reinforcement and reinforcement supports.

3.1.1.1.c Splices—Submit a list of splices and request to use splices not indicated in Contract Documents.

3.1.1.1.d Mechanical splices—Submit request to use mechanical splices not shown on the project drawings.

3.1.1.1.e Column dowels—Submit request to place column dowels without the use of templates.

3.1.1.1.f Field bending—Submit request and procedure to field bend or straighten reinforcement partially embedded in concrete.

3.1.1.1.g Certification—Submit copy of current CRSI Plant Certification Manual.

3.1.1.2 Submit the data specified in 3.1.1.2.a through 3.1.1.2.b when required:

3.1.1.2.a Welding—Submit description of reinforcement weld locations, welding procedures, and welder certification when welding is permitted in accordance with 3.2.2.2.

3.1.1.2.b Supports—If coated reinforcement is required, submit description of reinforcement supports and materials for fastening coated reinforcement not described in 3.2.2.4.

3.1.1.3 Submit the data specified in 3.1.1.3.a through 3.1.1.3.b when alternatives are proposed:

3.1.1.3.a Reinforcement relocation—Submit a request to relocate any reinforcement that exceeds specified placement tolerances.
3.1.3.3. b Inspection and quality-control program of plants applying epoxy coating if proposed plant is not certified in accordance with the CRSI Certification Program.

3.1.2 Materials delivery, storage, and handling

3.1.2.1 Prevent bending, coating with earth, oil, or other material, or otherwise damaging the reinforcement.

3.1.2.2 When handling coated reinforcement, use equipment having contact areas padded to avoid damaging the coating. Lift bundles of coated reinforcement at multiple pickup points to prevent bar-to-bar abrasion from sags in the bundles. Do not drop or drag coated reinforcement. Store coated reinforcement on cribbing that will not damage the coating.

3.2—Products

3.2.1 Materials

3.2.1.1 Reinforcing bars—Reinforcement shall be deformed bars, except spirals and welded wire reinforcement, which may be plain. Reinforcement shall be the grades, types, and sizes required by Contact Documents and shall conform to one of the following:

- ASTM A 615/A 615M;
- ASTM A 706/A 706M;
- ASTM A 970/A 970M; or
- ASTM A 996/A 996M, rail-steel bars shall be Type R.

3.2.1.2 Coated reinforcing bars—Use zinc or epoxy-coated reinforcing bars as specified in the Contract Documents.

3.2.1.2.1 Zinc-coated (galvanized) reinforcing bars shall conform to ASTM A 767/A 767M. Repair coating damage due to shipping, handling, and placing in accordance with ASTM A 780. The maximum total damaged areas shall not exceed 2% of the surface area in each linear foot of each bar.

3.2.1.2.2 Epoxy-coated reinforcing bars shall conform to ASTM A 775/A 775M or ASTM A 934/A 934M as specified in the Contract Documents.

Coatings shall be applied in plants that are certified in accordance with the Concrete Reinforcing Steel Institute (CRSI) Certification Program or an equivalent program acceptable to the Architect/Engineer.

Repair damaged areas with patching material conforming to ASTM A 775/A 775M or ASTM A 934/A 934M as applicable and in accordance with the material manufacturer’s written recommendations. Repair coating damage due to shipping, handling, and placing. The maximum total damaged areas shall not exceed 2% of the surface area in each linear foot of each bar. Fading of the coating color will not be cause for rejection of epoxy-coated reinforcing bars.

3.2.1.3 Stainless steel bars—Stainless steel bars shall conform to ASTM A 955/A 955M.

3.2.1.4 Bar mats—Bar mats shall conform to ASTM A 184/A 184M.

3.2.1.5 Wire—Use plain or deformed wire as indicated on Contract Documents. Plain wire may be used for spirals.

3.2.1.5.a Plain wire shall conform to ASTM A 82.

3.2.1.5.b Deformed wire shall conform to ASTM A 496.

3.2.1.5.c Epoxy-coated wire shall conform to ASTM A 884/A 884M. The maximum total damaged areas, including areas repaired at the manufacturing facility, shall not exceed 2% of the surface area in each linear foot of each wire. Repair all damaged areas.

3.2.1.5.d For wire with $f_y$ exceeding 60,000 psi, $f_y$ shall correspond to a strain of 0.35%.

3.2.1.6 Welded wire reinforcement—Use welded wire reinforcement specified in Contract Documents and conforming to one of the specifications given in 3.2.1.6.a through 3.2.1.6.c.

3.2.1.6.a Plain welded wire reinforcement—ASTM A 185, with welded intersections spaced not farther apart than 12 in. in the direction of principal reinforcement.

3.2.1.6.b Deformed welded wire reinforcement—ASTM A 497/A 497M, with welded intersections spaced not farther apart than 16 in. in the direction of principal reinforcement.

3.2.1.6.c Epoxy-coated welded wire reinforcement—ASTM A 884/A 884M, the maximum total damaged areas, including areas repaired at the manufacturing facility, shall not exceed 2% of the surface area in each linear foot of each wire. Repair all damaged areas.

3.2.1.6.d For welded wire reinforcement with $f_y$ exceeding 60,000 psi, $f_y$ shall correspond to a strain of 0.35%.

3.2.1.7 Wire-reinforcement supports—Unless otherwise specified or permitted, use wire-reinforcement supports complying with Class 1, maximum protection, or Class 2, moderate protection, as indicated in Chapter 3 of the CRSI Manual of Standard Practice.

3.2.1.8 Coated wire-reinforcement supports

3.2.1.8.a For epoxy-coated reinforcement—Use wire-reinforcement supports coated with dielectric material, including epoxy or another polymer for a minimum distance of 2 in. from the point of contact with epoxy-coated reinforcement.

3.2.1.8.b For zinc-coated reinforcement—Use galvanized wire-reinforcement supports or wire-reinforcement supports coated with dielectric material.

3.2.1.9 Precast concrete reinforcement supports—Use concrete supports that have a surface area of not less than 4 in.$^2$ and have a compressive strength equal to or greater than the specified compressive strength of the concrete being placed.

3.2.2 Fabrication

3.2.2.1 Reinforcement—Bend reinforcement cold unless heating is permitted. Fabricate reinforcement in accordance with fabricating tolerances of ACI 117.

3.2.2.2 Welding

3.2.2.2.a When welding of reinforcement is specified or permitted, comply with the requirements of ANSI/AWS D1.4. Do not weld crossing bars (tack welding) for assembly of reinforcement, supports, or embedded items.

3.2.2.2.b After completing welds on zinc-coated (galvanized) or epoxy-coated reinforcement, repair coating damage in accordance with requirements in 3.2.1.2.a or 3.2.1.2.b, respectively. Coat welds and steel splice devices used to splice reinforcement with the same material used for repair of coating damage.

3.3—Execution

3.3.1 Preparation

3.3.1.1 When concrete is placed, reinforcement shall be free of materials deleterious to bond. Reinforcement with
3.3.2 Placement

3.3.2.1 Tolerances—Place, support, and fasten reinforcement as shown on the project drawings. Do not exceed the placing tolerances specified in ACI 117 before concrete is placed. Placing tolerances shall not reduce cover requirements except as specified in ACI 117.

3.3.2.2 Reinforcement relocation—When it is necessary to move reinforcement beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embedded items, submit the resulting reinforcement arrangement for acceptance.

3.3.2.3 Concrete cover—Unless otherwise specified, minimum concrete cover for reinforcement shall be as indicated in Table 3.3.2.3.

For bundled bars, minimum concrete cover shall be equal to the equivalent diameter of the bundle but need not be greater than 2 in.; except the minimum cover shall not be less than specified in Table 3.3.2.3. The equivalent diameter of the bundle shall be computed based on the total area of the bundle. Tolerances on minimum concrete cover shall meet the requirements of ACI 117.

3.3.2.4 Reinforcement supports—Unless otherwise permitted, use the reinforcement supports given in 3.3.2.4.a through 3.3.2.4.i:

3.3.2.4.a Use precast concrete reinforcement supports to support reinforcement from the ground or a mud mat.

3.3.2.4.b Use reinforcement supports made of concrete, metal, or plastic to support uncoated reinforcement.

3.3.2.4.c Use wire reinforcement supports that are galvanized, coated with dielectric material, or made of dielectric material to support zinc-coated (galvanized) reinforcement.

3.3.2.4.d Reinforcement and embedded steel items used with zinc-coated (galvanized) reinforcement shall be zinc-coated (galvanized) or coated with nonmetallic materials.

3.3.2.4.e Support epoxy-coated reinforcement on coated wire reinforcement supports or on reinforcement supports made of dielectric material. Use coatings or materials compatible with concrete.

3.3.2.4.f When precast concrete reinforcement supports with embedded tie wires or dowels are used with epoxy-coated reinforcement, use wires or dowels coated with dielectric material.

3.3.2.4.g Reinforcement used as supports with epoxy-coated reinforcement shall be epoxy coated.

3.3.2.4.h In walls reinforced with epoxy-coated reinforcement, use spreader bars that are epoxy coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcement shall be made of corrosion-resistant material or coated with dielectric material.

3.3.2.4.i Fasten epoxy-coated reinforcement with tie wires coated with epoxy or other polymer.

3.3.2.5 Welded wire reinforcement—For slabs on ground, extend welded wire reinforcement to within 2 in. of the concrete edge. Lap splice edges and ends of welded wire reinforcement sheets as shown on the project drawings. Unless otherwise specified or permitted, do not extend welded wire reinforcement through contraction joints. Support welded wire reinforcement during placing of concrete to maintain positioning in the slab. Do not place welded wire reinforcement on grade and subsequently raise into position in concrete.

3.3.2.6 Column dowels—Furnish and use templates for placement of column dowels unless otherwise permitted.

3.3.2.7 Splices—Make splices as indicated on the project drawings unless otherwise permitted. Mechanical splices for reinforcement not shown on the project drawings shall not be used unless accepted by the Architect/Engineer. Remove reinforcement coating in the area of the mechanical splice if required by the splice manufacturer. After installing mechanical splices on zinc-coated (galvanized) or epoxy-coated reinforcement, repair coating damage and areas of removed coating in accordance with 3.2.1.2.a or 3.2.1.2.b. Coat exposed parts of mechanical splices used on coated bars with the same material used to repair coating damage.

3.3.2.8 Field bending or straightening—When permitted, bend or straighten reinforcement partially embedded in
Table 3.3.2.8—Minimum diameter of bend

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<th>Bar size</th>
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<tr>
<td>No. 3 through 8</td>
<td>Six bar diameters</td>
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<tr>
<td>No. 9, 10, and 11</td>
<td>Eight bar diameters</td>
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<tr>
<td>No. 14 and 18</td>
<td>Ten bar diameters</td>
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concrete in accordance with procedures 3.3.2.8.a through 3.3.2.8.c. Reinforcing bar sizes No. 3 through 5 may be bent cold the first time, provided reinforcing bar temperature is above 32 °F. For other bar sizes, preheat reinforcing bars before bending.

3.3.2.8.a Preheating—Apply heat by any method that does not harm the reinforcing bar material or cause damage to the concrete. Preheat a length of reinforcing bar equal to at least five bar diameters in each direction from the center of the bend but do not extend preheating below the surface of the concrete. Do not allow the temperature of the reinforcing bar at the concrete interface to exceed 500 °F. The preheat temperature of the reinforcing bar shall be between 1100 and 1200 °F. Maintain the preheat temperature until bending or straightening is complete. Measure the preheat temperature by temperature measurement crayons, contact pyrometer, or other acceptable methods. Do not artificially cool heated reinforcing bars until the temperature of the bar is less than 600 °F.

3.3.2.8.b Bend diameters—Minimum inside bend diameters shall conform to the requirements of Table 3.3.2.8. In addition, beginning of the bend shall not be closer to the concrete surface than the minimum diameter of bend.

3.3.2.8.c Repair of bar coatings—After field bending or straightening zinc-coated (galvanized) or epoxy-coated reinforcing bars, repair coating damage in accordance with 3.2.1.2.a or 3.2.1.2.b.

3.3.2.9 Field cutting of reinforcement—Field cut reinforcement only when specifically permitted using cutting methods specified by or acceptable to the Architect/Engineer. Do not flame cut epoxy-coated reinforcement.

3.3.2.9.a When zinc-coated (galvanized) reinforcing bars are cut in the field, coat the ends of the bars with a zinc-rich formulation used in accordance with the manufacturer’s recommendations, and repair any coating damage in accordance with 3.2.1.2.a.

3.3.2.9.b When epoxy-coated reinforcing bars are cut in the field, coat the ends of the bars with the same material used for repair of coating damage, and repair any coating damage in accordance with 3.2.1.2.b.

3.3.2.10 Reinforcement through expansion joint—Do not continue reinforcement or other embedded metal items bonded to concrete through expansion joints. Dowels bonded on only one side of a joint and waterstops shall extend through the joint.

SECTION 4—CONCRETE MIXTURES

4.1—General

4.1.1 Description—This section covers the requirements for materials, proportioning, production, and delivery of concrete.

4.1.2 Submittals

4.1.2.1 Mixture proportions—Submit concrete mixture proportions and characteristics.

4.1.2.2 Mixture proportion data—Submit field test records used to establish the required average strength in accordance with 4.2.3.3. Submit test data used to establish the average compressive strength of the mixture in accordance with 4.2.3.4.

4.1.2.3 Concrete materials—Submit the following information for concrete materials, along with evidence demonstrating compliance with 4.2.1:

- For cementitious materials: types, manufacturing locations, shipping locations, and certificates showing compliance with ASTM C 150, ASTM C 595, ASTM C 618, ASTM C 845, ASTM C 989, or ASTM C 1157.
- For aggregates: types, pit or quarry locations, producers’ names, gradings, specific gravities, and evidence not more than 90 days old demonstrating compliance with 4.2.1;
- For admixtures: types, brand names, producers, manufacturer’s technical data sheets, and certification data; and
- For water and ice: source of supply.

4.1.2.4 Field test data basis—When field test records are used as the basis for selecting proportions for a concrete mixture, submit data on materials and mixture proportions with supporting test results confirming conformance with specified requirements.

4.1.2.5 Mixture proportion adjustments—Submit any adjustments to mixture proportions or changes in materials, along with supporting documentation, made during the course of the Work.

4.1.2.6 Concrete for floors—Submit evaluations and test results verifying adequacy of concrete to be placed in floors when the cementitious materials content is less than that specified in Table 4.2.2.1.

4.1.2.7 Calcium chloride—When it is desired to use calcium chloride, submit a request including data demonstrating compliance with 4.2.2.5.

4.1.2.8 Volumetric batching—When it is desired to produce concrete by the volumetric batching method, submit request along with description of proposed method.

4.1.2.9 Time of discharge—When it is desired to exceed the maximum time for discharge of concrete permitted by ASTM C 94/C 94M, submit a request along with a description of the precautions to be taken.

4.1.3 Quality control

4.1.3.1 Maintain records verifying that materials used are of the specified and accepted types and sizes and are in conformance with the requirements of 4.2.1.

4.1.3.2 Ensure that production and delivery of concrete conform to the requirements of 4.3.1 and 4.3.2.

4.1.3.3 Ensure that the concrete produced has the specified characteristics in the freshly mixed state and that these characteristics are maintained during transport and delivery.

4.1.4 Materials storage and handling

4.1.4.1 Cementitious materials—Store cementitious materials in dry, weathertight buildings, bins, or silos that will exclude contaminants.
# OPTIONAL REQUIREMENTS CHECKLIST

<table>
<thead>
<tr>
<th>Section/Part/Article</th>
<th>Notes to Architect/Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General requirements</strong></td>
<td></td>
</tr>
<tr>
<td>1.6.3.2, 1.6.3.3, 1.6.4.1</td>
<td>Specify if other testing arrangements are required, such as Owner’s testing agency establishing mixture proportions or any testing responsibilities of the Owner’s testing agency that will be performed by the Contractor’s testing agency.</td>
</tr>
<tr>
<td>1.6.3.2.g, 1.6.4.2.e</td>
<td>If accelerated testing of concrete is specified or permitted as an alternative to standard testing, specify the procedure from ASTM C 684 that is to be followed. Specify when compressive test specimens are to be tested if other than seven and 28 days.</td>
</tr>
<tr>
<td>1.6.4.3</td>
<td>Specify additional testing services desired for the Work, if applicable. Note that these additional testing services are to be performed by the Owner’s testing laboratory; hence, the term “will” is used in place of “shall” in 1.6.4.3. Refer to ACI 311.1R (SP-2), ACI 311.4R, and 311.5R for specific inspection items that may be appropriate. When it is necessary or desirable to know properties of concrete at the point of placement or at locations other than the delivery point, specify that concrete is to be sampled at these other locations for testing. See the discussion under Optional Requirements in Section 4.2.2.2.</td>
</tr>
<tr>
<td>1.6.5.2</td>
<td>Specify if nondestructive tests will be permitted to evaluate uniformity or relative in-place strength of concrete. Refer to ACI 228.1R for guidance on nondestructive test methods.</td>
</tr>
<tr>
<td>1.6.7.1</td>
<td>If another basis for acceptance of concrete strength level is required for accelerated strength testing, specify the basis for acceptance.</td>
</tr>
<tr>
<td><strong>Formwork and formwork accessories</strong></td>
<td></td>
</tr>
<tr>
<td>2.1.2.1</td>
<td>Review the list of submittal items and specify in Contract Documents the items that need not be submitted.</td>
</tr>
<tr>
<td>2.1.2.2</td>
<td>Review the list of submittal items and specify in Contract Documents the items to be submitted.</td>
</tr>
<tr>
<td>2.2.1.1</td>
<td>Specify other materials for form faces in contact with concrete.</td>
</tr>
<tr>
<td>2.2.1.2</td>
<td>Indicate where walls require form ties with a positive water-barrier.</td>
</tr>
<tr>
<td>2.2.2.1</td>
<td>Specify if calculations and drawings for formwork must be sealed by a licensed Engineer.</td>
</tr>
<tr>
<td>2.2.2.3</td>
<td>Specify if earth cuts will be permitted or required.</td>
</tr>
<tr>
<td>2.2.2.4</td>
<td>Specify more or less stringent limitations on deflection of facing materials when needed. Refer to ACI 347 for further guidance.</td>
</tr>
<tr>
<td>2.2.2.5.b</td>
<td>Specify or allow alternative locations for formed construction joints when necessary to facilitate formwork removal or accelerate construction, provided that the alternative joint locations do not adversely affect the strength of the structure.</td>
</tr>
<tr>
<td>2.2.2.5.c</td>
<td>Specify keyway depths other than 1-1/2 in. when required.</td>
</tr>
<tr>
<td>2.2.3.2</td>
<td>Specify if chamfer strips are not required on exterior corners of permanently exposed surfaces. Specify if bevels are required on re-entrant corners of concrete or on edges of formed concrete joints.</td>
</tr>
<tr>
<td>2.3.1.2</td>
<td>Specify tolerance limits required to be different than those of ACI 117. Specify when a more or less restrictive tolerance for abrupt offset is required. Refer to ACI 347 and the Commentary to ACI 117 for further guidance.</td>
</tr>
<tr>
<td>2.3.2.5</td>
<td>Specify the minimum compressive strength for removal of forms supporting the weight of concrete if different than f'. Specify if nonload-carrying form-facing material is not permitted to be removed at an earlier age than the load-carrying portion of the formwork.</td>
</tr>
<tr>
<td>2.3.4.2</td>
<td>Specify if the alternative methods for evaluating concrete strength for formwork removal are permitted.</td>
</tr>
<tr>
<td><strong>Reinforcement and reinforcement supports</strong></td>
<td></td>
</tr>
<tr>
<td>3.1.1</td>
<td>Specify if the submittals listed in 3.1.1.1 through 3.1.1.3 are not required to be submitted. Otherwise, they will be required to be submitted.</td>
</tr>
</tbody>
</table>
| 3.2.1.1 | For headed bars, specify type of steel for reinforcing bars:  
- Low-alloy steel (ASTM A 706/A 706M);  
- Carbon steel (ASTM A 615/A 615M). For carbon steel (ASTM A 615/A 615M) also specify grade; and  
- Rail steel or axle steel deformed bars (ASTM A 996/A 996M). |
| 3.2.1.2 | Specify if coated reinforcing bars are required and, if so, whether the coating is to be zinc or epoxy. |
| 3.2.1.2.a | For zinc-coated reinforcing bars conforming to ASTM A 767/A 767M, specify the class of coating, whether galvanizing is to be performed before or after fabrication, and indicate which bars require special finished bend diameters (usually smaller sizes used for stirrup and ties). Avoid mixing galvanized and nongalvanized reinforcing steel or other embedded steel that could result in galvanic cells. |
| 3.2.1.2.b | Specify the ASTM specification to which epoxy-coated reinforcing bars are to conform. |
| 3.2.1.4 | Specify which of the three combinations will apply. |
| 3.2.1.5 | Specify plain or deformed wire and, if required, epoxy-coated wire. |
### OPTIONAL REQUIREMENTS CHECKLIST (cont.)

<table>
<thead>
<tr>
<th>Section/Part/Article</th>
<th>Notes to Architect/Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.1.6</td>
<td>Specify plain or deformed welded wire reinforcement and, if required, epoxy-coated wire reinforcement. Refer to “WRI Manual of Standard Practice” for additional guidance.</td>
</tr>
<tr>
<td>3.2.1.7</td>
<td>Specify if wire reinforcement supports are required or permitted.</td>
</tr>
<tr>
<td>3.2.2.2</td>
<td>Specify if bar welds are required or permitted. If required or permitted, specify any desired requirements for preparation for welding (such as removal of zinc or epoxy coating) more stringent than those in AWS D1.4. Specify desired requirements for chemical composition of reinforcing bars more stringent than those of the referenced ASTM specifications. Specify special heat treatment of welded assemblies, if required. Specify supplementary requirements for welding of wire to wire, and welding of wire or welded wire reinforcement to reinforcing bars or structural steels.</td>
</tr>
<tr>
<td>3.3.2.3</td>
<td>Specify special cover requirements for corrosive atmosphere, other severe exposures, or fire protection not covered in Table 3.3.2.3. Some concrete covers in Table 3.3.2.3 may exceed minimum concrete covers required by ACI 318. Concrete covers used for design must agree with the covers specified in Table 3.3.2.3.</td>
</tr>
<tr>
<td>3.3.2.4</td>
<td>Specify if the methods of support are to be other than those indicated in 3.3.2.4.a through 3.3.2.4.i.</td>
</tr>
<tr>
<td>3.3.2.5</td>
<td>Specify where reinforcement may extend through contraction joints, including saw-cut joints.</td>
</tr>
<tr>
<td>3.3.2.8</td>
<td>Specify if bending or straightening reinforcement partially embedded in concrete is permitted.</td>
</tr>
<tr>
<td>3.3.2.9</td>
<td>Specify if field cutting of reinforcement is permitted and specify cutting methods to be used.</td>
</tr>
</tbody>
</table>

### Concrete mixtures

| 4.2.1.1              | Specify the test for determining conformance to requirements for cleanliness, and specify grading be performed on samples obtained from the aggregates at the point of batching. Specify any additional requirements for aggregate such as hardness, color, mineralogical composition, texture, or shape (crushed or gravel). If concrete will be exposed to wetting, extended exposure to humid atmosphere, or in contact with moist ground, specify the use of aggregates that do not contain materials deleteriously reactive with alkalis in the cement; however, such aggregates may be used with cement containing less than 0.60% alkalis such as (Na₂O + 0.658K₂O) or with a material such as natural pozzolan, fly ash, slag, or silica fume in an amount shown to be effective in preventing harmful expansion due to alkali-aggregate reaction in accordance with ASTM C 441. Alternatively, specify a low-alkali cement be used as described in the Optional Requirements Checklist for 4.2.1.2. |
| 4.2.1.2              | Specify special cover requirements for corrosive atmosphere, other severe exposures, or fire protection not covered in Table 3.3.2.3. Some concrete covers in Table 3.3.2.3 may exceed minimum concrete covers required by ACI 318. Concrete covers used for design must agree with the covers specified in Table 3.3.2.3. |
| 4.2.1.3              | Specify the test for determining conformance to requirements for cleanliness, and specify grading be performed on samples obtained from the aggregates at the point of batching. Specify any additional requirements for aggregate such as hardness, color, mineralogical composition, texture, or shape (crushed or gravel). If concrete will be exposed to wetting, extended exposure to humid atmosphere, or in contact with moist ground, specify the use of aggregates that do not contain materials deleteriously reactive with alkalis in the cement; however, such aggregates may be used with cement containing less than 0.60% alkalis such as (Na₂O + 0.658K₂O) or with a material such as natural pozzolan, fly ash, slag, or silica fume in an amount shown to be effective in preventing harmful expansion due to alkali-aggregate reaction in accordance with ASTM C 441. Alternatively, specify a low-alkali cement be used as described in the Optional Requirements Checklist for 4.2.1.2. |
| 4.2.1.4              | Specify the admixtures listed in 4.2.1.4 that are required. Indicate the parts of the Work in which each type of admixture should or may be used. |
| 4.2.2.1              | Specify if less than 15% or more than 25% fly ash is permitted in floors. If more than 25% is permitted, a history should be available demonstrating the finishing ability of the proposed concrete mixture. |
Specifications for Tolerances for Concrete Construction and Materials and Commentary

An ACI Standard

Reported by ACI Committee 117

ACI Committee 117-06 supersedes ACI 117-90 and became effective August 15, 2006.

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PREFACE

P1. ACI Specification 117 is intended to be used by reference or incorporation in its entirety in the Project Specification. Do not copy individual Parts, Sections, Articles, or Paragraphs into the Project Specification because taking them out of context may change their meaning.

P2. If Sections or Parts of ACI Specification 117 are copied into the Project Specification or any other document, do not refer to them as an ACI Specification because the specification has been altered.

P3. A statement such as the following will serve to make ACI Specification 117 a part of the Project Specification: “Work on (Project Title) shall conform to all requirements of ACI 117-06 published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these Contract Documents.”

P4. The language in each technical Section of ACI Specification 117 is imperative and terse.
SECTION 2—MATERIALS

STANDARD

2.1—Reinforcing steel fabrication

For bars No. 3 through 11 (No. 10 through 36) in size, refer to Fig. 2.1(a).

For bars No. 14 and 18 (No. 43 and 57) in size, refer to Fig. 2.1(b).

---

**TOLERANCE SYMBOLS**

1 = ±1/2 in. (15 mm) for bar size No. 3, 4, and 5 (No. 10, 13, and 16) (gross length < 12 ft. 0 in. (3660 mm))
2 = ±1 in. (25 mm) for bar size No. 3, 4, and 5 (No. 10, 13, and 16) (gross length ≥ 12 ft. 0 in. (3660 mm))
3 = ±1 in. (25 mm) for bar size No. 6, 7, and 8 (No. 19, 22, and 25)
4 = ±1 in. (25 mm) for diameter < 30 in. (760 mm)
5 = ±1 in. (25 mm) for diameter ≥ 30 in. (760 mm)
6 = ±1.5% "C" dimension, ≥ 2 in. (50 mm) minimum

**Note:** All tolerances single plane and as shown.

Dimensions on this line are to the within tolerance shown but are not to dif-
fer from the opposite parallel dimension more than 1/2 in. (15 mm).
Angular deviation—maximum ±15 degrees or ±1.5 in. (40 mm),
but not less than 1/2 in. (15 mm) on all 90 degree hooks and bends.
If application of positive tolerance to Type B results in a chord length > the
arc or bar length, the bar may be shipped straight.
Tolerances for Types B1-55, G1-7, H1-73, H6-79 apply to bar size No. 3
through 8 (No. 10 through 25) inclusive only.

---

*Fig. 2.1(a)—Standard fabricating tolerances for bar sizes No. 3 through 18 (No. 10 through 57).*
Fig. 2.1(a) (cont.)—Standard fabricating tolerances for bar sizes No. 3 through 11 (No. 10 through 36).
TOLERANCES FOR CONCRETE CONSTRUCTION

STANDARD

STRAIGHT

![Diagram of various tolerances for concrete construction]

TOLERANCE SYMBOLS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>No. 14 (No. 43)</th>
<th>No. 18 (No. 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>± 2-1/2 in. (65 mm)</td>
<td>± 3-1/2 in. (90 mm)</td>
</tr>
<tr>
<td>8</td>
<td>± 3 in. (80 mm)</td>
<td>± 2 in. (50 mm)</td>
</tr>
<tr>
<td>9</td>
<td>± 1-1/2 in. (40 mm)</td>
<td>± 2 in. (50 mm)</td>
</tr>
<tr>
<td>10 = 2% x &quot;O&quot;</td>
<td>± 2-1/2 in. (55 mm) min.</td>
<td>± 3-1/2 in. (90 mm) min.</td>
</tr>
</tbody>
</table>

Note: All tolerances single plane as shown.

Saw-cut both ends—Overall length ± 1/2 in. (15 mm).

Angular deviation—Maximum ± 2 1/2 degrees or ± 1/2 in./ft (40 mm/m) on all 90 degree hooks and bends.

If application of positive tolerance to Type 9 results in a chord length ≥ the arc or bar length, the bar may be shipped straight.

Fig. 2.1(b)—Standard fabricating tolerances for bar sizes No. 14 and 18 (No. 43 and 57).
STANDARD

2.2—Reinforcement location

2.2.1 Placement of nonprestressed reinforcement, measured from form surface

When member depth (or thickness) is 4 in. (101 mm) or less..............................................±1/4 in. (6 mm)

When member depth (or thickness) is over 4 in. (101 mm) and not over 12 in. (305 mm) ..........±3/8 in. (10 mm)

When member depth (or thickness) is over 12 in. (305 mm)................................................±1/2 in. (13 mm)

2.2.2 Concrete cover measured perpendicular to concrete surface

When member depth (or thickness) is 12 in. (305 mm) or less..............................................−3/8 in. (10 mm)

When member depth (or thickness) is over 12 in. (305 mm)..............................................−1/2 in. (13 mm)

Reduction in cover shall not exceed 1/3 the specified concrete cover.

Reduction in cover to formed soffits shall not exceed ............................................................−1/4 in. (6 mm)

2.2.3 Vertical deviation for slab-on-ground reinforcement.........................................................± 3/4 in. (19 mm)

COMMENTARY

R2.2—Reinforcement location

In the absence of specific design details shown or specified on the contract documents, CRSI MSP-I, Appendix C, should be followed by estimators, detailers, and placers. The tolerance for $d$ as stated in ACI 318, is a design tolerance and should not be used as a placement tolerance for construction.

R2.2.1, R2.2.2, and R2.2.3 Tolerances for fabrication, placement, and lap splices for welded wire reinforcement are not covered by ACI 117 and, if required, should be specified by the specifier. There is an inherent conflict in the measurement of tolerances relating to reinforcing steel. During placement of reinforcing steel, tolerances are measured from formwork or the intended future concrete finish. After a structure is complete, tolerances are measured against hardened concrete. Refer to Fig. R2.2.1(a), (b), and (c). An absolute limitation on one side of the reinforcement placement is established by the limit on the reduction in cover. Refer to Fig. R2.2.2(a) to (d) and Fig. R2.2.3.

Fig. R2.2.1—Placement.
STANDARD

COMMENTARY

Fig. R2.2.2—Cover.

Fig. R2.2.3—Vertical placement.
### STANDARD

2.2.4 Clear distance between reinforcement or between reinforcement and embedment

One-quarter specified distance not to exceed ±1 in. (25 mm)

Distance between reinforcement shall not be less than the greater of the bar diameter or 1 in. (25 mm) for unbundled bars.

For bundled bars, the distance between bundles shall not be less than the greater of 1 in. (25 mm) or 1.4 times the largest individual bar diameter for two-bar bundles, 1.7 times the largest individual bar diameter for three-bar bundles, and two times the largest individual bar diameter for four-bar bundles.

2.2.5 Spacing of nonprestressed reinforcement, measured along a line parallel to the specified spacing

In slabs and walls, except as noted below ±3 in. (76 mm)

Stirrups ......... the lesser of ±3 in. (76 mm) or ±1 in. per ft of beam depth (83 mm per 1 m)

Ties ............. the lesser of ±3 in. (76 mm) or ±1 in. per ft of least column width (83 mm per 1 m)

The total number of bars shall not be less than that specified.

### COMMENTARY

R2.2.4 and R2.2.5 The spacing tolerance of reinforcement consists of an envelope with an absolute limitation on one side of the envelope determined by the limit on the reduction in distance between reinforcement. In addition, the allowable tolerance on spacing should not cause a reduction in the specified number of reinforcing bars used. Designers are cautioned that selecting a beam width that exactly meets their design requirements may not allow for reinforcement placement tolerance. This sometimes happens when lap-spliced bars take up extra space and cannot accommodate the placement tolerance. Where reinforcement quantities and available space are in conflict with spacing requirements of these sections, the contractor and designer might consider bundling a portion of the reinforcement. Bundling of bars requires approval of the designer. Refer to Fig. R2.2.4(a) to (e) and R2.2.5.

<table>
<thead>
<tr>
<th>Diameter of Bar</th>
<th>D = Diameter derived from combined area of all bars in one bundle</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Clear distance between reinforcement</td>
</tr>
<tr>
<td>(b)</td>
<td>Diameter of Bar = D</td>
</tr>
<tr>
<td>(c)</td>
<td>(1.4 * D) ≥ 1 in. (25 mm)</td>
</tr>
<tr>
<td>(d)</td>
<td>(1.7 * D) ≥ 1 in. (25 mm)</td>
</tr>
<tr>
<td>(e)</td>
<td>(2 * D) ≥ 1 in. (25 mm)</td>
</tr>
</tbody>
</table>

**Fig. R2.2.4—Clear distance.**
2.2.6 Placement of prestressing reinforcement or prestressing ducts

2.2.6.1 Horizontal deviation

Element depth (or thickness) 24 in. (0.6 m) or less ........................................................... ±1/2 in. (13 mm)

Element depth (or thickness) over 24 in. (0.6 m) ........................................................... ±1 in. (25 mm)

2.2.6.2 Vertical deviation

Element depth (or thickness) 8 in. (203 mm) or less ........................................................... ±1/4 in. (6 mm)

Element depth (or thickness) over 8 in. (203 mm) and not over 24 in. (0.6 m) ....................... ±3/8 in. (10 mm)

Element depth (or thickness) more than 24 in. (0.6 m) ........................................................... ±1/2 in. (13 mm)

2.2.7 Longitudinal location of bends in bars and ends of bars

At discontinuous ends of corbels and brackets ........................................................... ±1/2 in. (13 mm)

At discontinuous ends of elements ...... ±1 in. (25 mm)

At other locations .............................................. ±2 in. (51 mm)

R2.2.6 The vertical deviation tolerance should be considered in establishing minimum prestressing tendon covers, particularly in applications exposed to deicer chemicals or salt water environments where use of additional cover is recommended to compensate for placing tolerances. Slab behavior is relatively insensitive to horizontal location of tendons. Refer to Fig. R2.2.6(a) and (b).

R2.2.7 and R2.2.8 The tolerance for the location of the ends of reinforcing steel is determined by these two sections.
2.2.8 **Embedded length of bars and length of bar laps**

No. 3 through 11 (No. 10 through 36) bar sizes
..............................................................−1 in. (25 mm)

No. 14 and 18 (No. 43 and 57) bar sizes
..............................................................−2 in. (51 mm)

2.2.9 **Bearing plate for prestressing tendons, deviation from specified plane** ....... The lesser of ±1/8 in. (3 mm) or ±1/4 in. per ft (20 mm per 1 m)

2.2.9 The tolerance for conformance of prestressing tendon bearing plates to the specified plane is established by this section. Refer to Fig. R2.2.9.

![Fig. 2.2.9—Bearing plate for prestressing tendons.](image)

2.2.10 **Placement of smooth dowels in slabs-on-ground**

2.2.10.1 Centerline of dowel, vertical deviation measured from bottom of concrete slab at the joint
..............................................................±1/2 in. (13 mm)

When element dimension is over 2 ft (0.6 m)
..............................................................±1 in. (25 mm)

2.2.10.2 Spacing of dowels ..............±3 in. (76 mm)

The total number of dowels shall not be less than that specified.

2.2.10.3 Centerline of dowel with respect to a horizontal line that is perpendicular to the plane established by the joint

Horizontal deviation........................................±1/4 in. (6 mm)

Vertical deviation........................................±1/4 in. (6 mm)

R2.2.10 The tolerance for placement of dowels is determined by this section. Refer to Fig. R2.2.10.1, R2.2.10.2, and R2.2.10.3.

![Fig. R2.2.10.1—Dowel placement.](image)

![Fig. R2.2.10.2—Dowel spacing.](image)

![Fig. R2.2.10.3—Dowel deviation from line.](image)
Sloped Versus Stepped Footings for Walls

Generally, it's most economical to place wall footings at a constant elevation. If the site or finished grade slopes along the length of the wall, however, the footing may end up a considerable distance below finished grade. This is clearly not economical, as it requires extra excavation and material. Two other options are therefore preferred (Fig. 1):

- Slope the footing with the site so its depth below the finished grade is nearly constant along its length; or
- Step the footing so its depth below finished grade is not excessive at any point along its length.

SLOPED FOOTING ISSUES

The sloped footing option may seem appealing because of the simple geometry and apparent ease in formwork construction. It does, however, create the following construction issues (Fig. 2):

- Vertical wall bars above the footing will have different lengths, creating major challenges in the fabrication plant and on the job site. Two of these—managing the inventory and placing the bars in their correct locations—can be eased by detailing the bars with variable lap splice lengths. This will, however, increase the quantity of vertical reinforcement;
- Horizontal reinforcing bars in the lower portion of the wall will also have different lengths because they are interrupted by the sloped footing. If constant length horizontal bars are used at the wall base, they can be fanned out, but this will create a variable vertical spacing of the reinforcing bars;
- Sloped footings will require trapezoidal formwork. This will require modifications to standard rectangular formwork;
- A sloped footing could be unstable, particularly on a very steep slope; and
- Concrete placement and finishing could be difficult, and a stiff concrete mixture might be required to prevent the concrete from flowing downhill, which may lead to segregation. Alternatively, the top of the form may have to be closed.

Because of these challenges, most engineers and contractors prefer to use stepped footings instead of sloped footings.

CONSIDERATIONS FOR STEPPED FOOTINGS

As with any aspect of a design, cost should be considered before a system is selected. If the slope of the finished grade is less than 2 ft (0.6 m) for a 20 to 30 ft (6 to 9 m) long wall, a lower but constant bottom bearing
Fig. 1: There are two ways to construct footings for walls built at sloping grades: (a) slope the footing to match the change in finished grade elevation; or (b) step the footing at intervals that maintain the minimum footing depth.

Fig. 2: Construction issues for sloped footings

Fig. 3: Preferred details for stepped footings

Elevation may be more economical than a stepped footing. For a very long wall, however, even a 1 ft (0.3 m) variation in the site elevation may make a stepped footing more economical. Communication with the contractor during the design phase regarding the number and length of steps can be very helpful.

It’s generally more cost effective to minimize the number of steps. For example, it may be more economical to design for a 6 ft (1.8 m) change in elevation using three 2 ft (0.6 m) steps or two 3 ft (0.9 m) steps rather than six 1 ft (0.3 m) steps. This minimizes the number of wall sections to be detailed and formed. Before deciding on the footing step locations, however, consider the horizontal distance between them. Distances should preferably be multiples of available or standard form lengths.

Before completing a design, it’s a good idea to communicate with area formwork contractors. The horizontal runs should be dimensioned in 2 or 4 ft (0.6 or 1.2 m) increments to conform to standard plywood or form system dimensions. Unless the site slopes drastically, try to keep a minimum horizontal run of 10 ft (3 m) for each step, if possible.

Keep the detailing simple. Avoid using Z-shaped bars (Fig. 3). Their geometry may make it necessary to slant the riser out of plane to meet cover requirements for the treads.

It’s also prudent to evaluate other footing options. For example, the individual spread footings or piers supporting grade beams shown in Fig. 4 may be more economical than a continuous spread footing option. Because the wall can span between footings or piers, similar configurations can be constructed without the grade beam.

Situations can vary along the wall length, so it’s prudent to show specific details rather than generic details. This will expedite placing drawing preparation and perhaps minimize requests for information (RFIs).
Fig. 4: Isolated spread footings or drilled piers, with or without a grade beam connecting them, are an alternative to sloped or stepped footings

**CLOSURE**

The use of sloped or stepped footings depends on site conditions, finished grade elevations, finished wall slope, and various reinforcing bar placement and construction issues. Regardless of the footing system selected, the engineer is required to follow the design requirements of Section 15.9 in ACI 318-08. Section 15.9.1 requires that the angle of slope or depth and location of steps be such that the design requirements are satisfied at every section. Additionally, Section 15.9.2 requires footings designed as a unit to be constructed to ensure they act as a unit.

**References**

1. ACI Committee 318, “Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary,” American Concrete Institute, Farmington Hills, MI, 2008, 465 pp.

*Thanks to Joint ACI-CRSI Committee 315 member Javed Malik, Jacobs Carter Burgess Engineering, Houston, TX, for providing the information in this article.*

Selected for reader interest by the editors.
February 25, 2009

From: Dick Birley
Subject: 315B – Constructibility Task Group – Issues regarding Nuclear Verbatim Compliance
Members: Dennis Hunter, Robbie Hall, Greg Birley, Jay Hetherington, Dick Birley
To: Committee 315 – Detailing

At the Committee 315 meeting Nov 2, 2008, in St. Louis, Greg Birley raised the issue of Nuclear Verbatim Compliance. Condor Rebar Consultants Inc has been experiencing difficulties having its detailing approved because numerous bar shapes we have called up are not found in ACI Detailing Manual – 2004. The reviewers, noting that there must be Verbatim Compliance to all codes and standards, take the view that if a bar shape is not shown in the Manual it is therefore a non-complying shape. In every instance a Non-Compliance Report is issued against Condor. We must then issue an RFI asking for the non-complying shape to be approved for use on the project.

It is clear that construction of nuclear reactors is about to make a remarkable comeback. It is therefore important for the entire reinforcing steel industry that this Committee resolve this bar shape issue as quickly as possible.

To that end, a Task Group was struck to develop a solution. We are pleased to submit the following report.

Regards,
Dick Birley, Chairman
Verbatim Compliance as defined by QA/QC programs on recent nuclear construction projects means that any bend shape that is not described in the ACI Detailing Manual – 2004 list of typical bar bends is a non-complying bar. In each instance, an RFI requesting approval of the shape must be issued. This Task Group was charged with the task of recommending changes to the ACI Detailing Manual that would cover all possible bar shapes.

TASK GROUP RECOMMENDATIONS

The Task Group makes four general recommendations: reorganize the section of the Manual dealing with bar shapes to show a more logical progression of data, make a general statement about Typical Bar Bends, modify "Notes:" on pages 32 and 33, and present a guideline for all bend shapes.

Organization of Detailing Manual

Present bar bend data in the following order:

1. Typical Bar Bends (Pages 32 and 33 in current manual)
2. Hook Data (Pages 43 and 44 in current manual)
3. Guidelines for Bar Bends (Presented in this document)
4. Fabrication Tolerances (Pages 29, 30 and 31 in current manual)

Typical Bar Bends Statement

Insert the following qualifying statement on current Pages 29 through 33:

"The typical bar bends shown above represent only the most common shapes encountered in normal concrete construction. It is possible that other shapes will be required. Other shapes are acceptable provided they follow the conventions listed in "Guidelines for Bar Bends" on Page ___." 

Modify “Notes:"

Rearrange and modify "Notes:" on pages 32 and 33 to read as follows:

1. Figures in circles show types.
2. All dimensions are out-to-out of bar except “A” and “G” on standard 180° and 135° hooks.
3. “J” dimensions on 180° hooks to be shown only where necessary to restrict hook size; otherwise ACI standard hooks are to be used.
4. Where “J” is not shown, “J” will be kept equal to or less than “H” on Types such as 3, 5, and 22. Where “J” can exceed “H”, it should be shown.
5. “H” dimension stirrups to be shown where necessary to fit within concrete.
6. Where bars are to be bent more accurately than standard fabricating tolerances, bending dimensions that require closer fabrication should have limits indicated.
7. For recommended diameter "D" of bends and hooks, see Section 3.7.1; for recommended hook dimensions, hook dimensions, see Table 1.
8. Type S1 through S8, S11, T1 through T3, and T6 through T9, apply to bar sizes No. 3 through 8 (No. 10 through 25).
9. Unless otherwise noted, diameter “D” is the same for all bends and hooks on a bar (except for Types such as 11 and 13).
Guidelines for Bar Bends

- Stirrups and ties confining vertical or longitudinal bars in members such as columns and beams are treated as "S" and "T" shapes in the Typical Bar Bends schedule and are bent on pin sizes listed in the schedules on Page 44 of the current ACI Detailing Manual – 2004.

- A and G leg dimensions always denote standard hooks as defined by ACI 318 except for types such as 10, 14, and T3. (See P44 in the current ACI Detailing Manual – 2004.

- Leg dimensions A through G are additive dimensions that are used to produce total length.

- Leg dimensions H, J, K, O and R are always descriptive dimensions and are not added into the total length. Generally, though not necessarily always, these dimensions are used as described below:
  - H – height (vertical dimension) of a sloping leg
    - (except for types such as S1, S2 and S3 where it is the depth of the hook)
    - (height of types such as 9, 11, 25 and S11)
  - J – depth of hook
    - (may be used in lieu of H when multiple sloping legs with different angles are required)
  - K – width (horizontal dimension) of a sloping leg
  - O – Overall length
    - (may be used in lieu of K when multiple sloping legs with different angles are required)
  - R – radius
    - Multiple sloping legs on a single bar may also be described as H/K, H1/K1, H2/K2, etc.

- Leg dimensions F and R may not be used together on the same bar type.

- If a bar type contains two hooks, they must both be of the same class, i.e. either standard hooks or stirrup/tie hooks.

- Types "25", "26", and other shapes used as standees are treated the same as "S" and "T" bend types for bending purposes, i.e. bent on smaller pins than regular bend shapes.

- For legs of all bend shapes, except for end hooks, labeling begins with “B” and follows in sequence to “F” for succeeding sides with no letters omitted. There may be exceptions such as Type 7.

- A bar shape may be called up with sides omitted to achieve a desired shape. For example, a bar with a single standard hook may be described as Type 2 with only “A” and “B” dimensions indicated. A corner bar may be described as Type 17 with only “B” and “C” dimensions indicated.

- Identical sides on combination ties are labeled with the same letter as illustrated in Sketch 1.

- Measurement of bent bars to be as follows:
  - All dimensions are measured out-to-out except for sides “A” and “G” which are measured as indicated on Page 44 of the current ACI Detailing Manual – 2004
  - Straight bars are measured end to end as shown in Sketch 2
  - Bends between 1° and 89° measured to intersection of sides as shown in Sketch 3
  - 90° bends measured to intersection of sides as shown in Sketch 4
  - Bends between 91° and 179° measured to tangents of bend as shown in Sketch 5
  - 180 bends measured to sides and tangent as shown Sketch 6
  - “Z” bars measured to intersection of sides as shown on Sketch 7
Combination or 'multi' tie

Sketch 1

Sketch 2

Sketch 3

Bends between 1 and 89 degrees

Sketch 4

Sketch 5

Bends between 91 and 179 degrees

Sketch 6

Sketch 7

"Z" bar

180 degree bends

90 degree bends

Straight Bars