ACI COMMITTEE 439 on REINFORCING STEEL
MEETING NOTICE AND AGENDA

To: Members of ACI Committee 439
From: Mark D. Marvin, Chair e-mail: mdm.tmg@comcast.net
William C. Gallenz, Secretary e-mail: wgallenz@rsinc.bz
Date 27 October 2008

Address Chairman at:
The Marvin Group, Inc.
P.O. Box 1259 Fairacres, NM 88033
Phone 859-371-8009 Fax: 859-371-8013
e-mail: mdm.tmg@comcast.net

ACI COMMITTEE 439 MEETINGS SUMMARY
Fall 2008 — St. Louis, MO, Renaissance Grand and America's Center

COMMITTEE NUMBER	COMMITTEE NAME	DAY	TIME	ROOM
439	Steel Reinforcement	Mon, Nov 3	8:30a-10p	Hawthorne
439-A	Steel Reinf-Wire	Sun, Nov 2	3:30p-5p	Kingsbury

AGENDA -- COMMITTEE 439 ON STEEL REINFORCEMENT
(Main committee meeting on Monday, 3 November 2008)

1. Call to order and introductions
2. Membership overview
3. Approval of minutes from Spring 2008 meeting in Century City, CA
4. Stainless Steel Rebar Alloy Presentation – Mr. Phil Zivich, Outokumpu Stainless
5. Subcommittee reports
   5.1. 439 A on Welded Wire Reinforcement – Ted Mize, Chair; Ryan Pelter, Secretary
6. Task Group Reports
   6.1. Field straightening reinforcement: testing status update – Mario Rodriquez, Chair
   6.2. "Steel Reinforcement - Physical Properties & U. S. Availability" (ACI 439.4R-89)
   Update on TAC Comments Status
   6.3. New high strength steel – Salem Faza, Chair
   6.4. Staggering splices – Lou Colarusso, Chair – Update
   6.5. Review of committee comments for "Comprehensive Guide…" (attached)
7. Review of Mission Statement and Goals
8. Other Old Business
9. New Business
10. Adjournment

cc: D. Johnston, TAC Contact
Dan Falconer, ACI Engineering manager, Attn: Pat Levicki

DRAFT MINUTES FOR ACI COMMITTEE 439

March 31, 2008

Address writer at:
Reinforcement Solutions, Inc.
1117 N. 23rd Street
Allentown, PA 18104

To: Members of ACI 439
From: William C. Gallenz, Secretary E-mail: wgallenz@rsinc.bz

Subject: 439 Main Committee minutes for the meeting held:
Monday, March 31, 2008 (8:30am – 10:00am)
Los Angeles, CA, Hyatt Regency Century Plaza, Encino

1. Call to order: 8:30 A.M.

2. Attendance:

2.1. Voting Members Present: M. Marvin, W. Gallenz, J. Bohinsky, C. Agusta, L. Colarusso, D. DeValve, S. Faza, A. Felder, T. Hawkinson, S. Holdsworth, K. Luttrell, L. Lutz, T. Mize, C. Paulson, R. Pelter, R. Ramsey, R. Reiterman, M. Rodriguez, D. Starnes, W. Zehrt

2.2. Voting Members Absent: D. Carreira, P. Fredrickson, A. Hulshizer, H. Lancelot, P. Meza, R. Richardson, P. Ross, C. Sabo, R. Smith, K. Williamson

2.3. Other Members Present: J. Braun, M. Thompson

2.4. Visitors Present: J. Galli, J. Hetherington, B. Barrows, S. Johnson, H. Sezen, A. Adedurain, R. Gnanasekaran, M. Raymunno

2.5. Summary: 20 Voting Members present, 10 Voting Members absent, 2 Other Members present, 8 Visitors present.

2.5.1. As of the date of the meeting, committee membership stood at 30 Voting, 3 Associate and 6 Consulting members.

3. Minutes Approval:

3.1. The minutes as presented from the Fall, 2007 Fajardo, PR meeting were unanimously approved. (Motion: J. Bohinsky; Second: L. Colarusso)

4. Subcommittee Reports:

4.1 439-A on Wire Reinforcement (T. Mize, Chair, R. Pelter, Secretary) – Subcommittee A met on Sunday March 30, 2008.

4.1.1 Attendance: There were 11 in attendance. 10 members, 1 visitor.

4.1.2 Changes to ACI 318

4.1.2.1 T. Mize noted an increase in transverse reinforcement strength to 100ksi.

4.1.2.2 T. Mize confirmed limited use of D45 due to ongoing lap test requirements. Plain wire requirements only can be used for wire greater than D31.0. M. Marvin confirmed the change for lap calculation.

4.1.2.3 Proposed changes for 318-11 include consideration of maximum wire spacing of 16” on deformed WWR and 12” on plain WWR. The committee discussed the suggestion of wire sizes smaller than D4.

4.1.2.4 Discussion and report on proposed ACI Guide document. M. Marvin stated that the physical properties guide has been approved, but comments will need to be addressed. Key words will also need to be developed.

4.1.2.5 Subcommittee review of goals included a potential session on constructability and a session on ACI Guide document.

4.1.2.6 T. Mize updated ASTM Standards.

5 Task Group Reports:

5.1 Field straightening reinforcement: testing status update – Mario Rodriquez, Chair

5.1.1 M. Rodriguez is just re-starting the process.

5.1.2 M. Marvin to take off fall agenda until Rodriquez progresses.

5.1.3 ASTM to close in April about coiled rebar.

5.1.3.1 L. Colarusso to email ASTM information to M. Rodruquez.

5.2 Report "Steel Reinforcement – Physical Properties & U.S. Availability" (ACI 439.4R-89) (L. Lutz, Chair) resolved negative comments.

5.2.1 TAC has approved the document pending resolution of the primary, secondary and editorial comments. There were 17 primary comments, 7 secondary comments and 45 editorial comments.

5.2.2 The committee discussed all primary comments and Leroy Lutz will make the necessary changes to the document.

5.2.3 The document will be re-balloted on only the items commented on by TAC. Once Ballot is approved, a revised edition will be sent to TAC.

5.3 New High Strength Steel (S. Faza, Chair)

5.3.1 Still working on report to be available in a few weeks.

5.3.2 Upcoming conference in Japan about high strength steel.

5.4 Staggering Splices Update (L. Colarusso, Chair)

5.4.1 Document passed through sub-committed vote and soon to be issued to 439 main.

5.4.2 Document will be sent to committee 408.

6 Review of Mission Statement and Goals (ACI Requirement):

6.1 The mission and goals remain as defined at fall 2007 meeting.

7 Other Old Business:

7.1 No additional old business discussed.

8 New Business:

8.1 No new business discussed.

9 Adjournment:

9.1 T. A. Feldner motioned, D. DeValve second.

cc: D. Johnston, TAC Contact
Ron Burg, TAC Chair
Dan Falconer, ACI Engineering manager, Attn: Shannon Banchero

ACI SUBCOMMITTEE 439-A AGENDA

October 24, 2008

To: Members of ACI Subcommittee 439-A

From: Theodore A. Mize, Chairman
Ivy Steel & Wire
815 Bethany Lane
Concord, CA 94518

Phone and Fax: 925-685-9141 Email: tamize@sbcglobal.net

Date: Sunday, November 2, 2008
Place: St. Louis, MO – Renaissance Grand and Suites Hotel – Kingsbury
Time: 3:30 – 5:00pm

1 – Call to order.

2 – Introduction and welcome guests and new members.

3 – Approval of minutes from the Los Angeles meeting (attached).

4 – Subcommittee membership update.

5 – Changes to ACI 318.
a. Proposals for material and use related changes to next 318 Code.
b. Re-initiate request for elimination of deformed WWR spacing limitation.

6 – Discussion/report on proposed ACI Guide document.

7 – Subcommittee review of implementation goals.
a. Discuss educational plan and timeline – coordinate with guide document.
b. Discuss new ideas for subcommittee goals, mission statement.

8 – Report on new or revised ASTM Standards.

9 – Address comments on Wire and WWR Guide document.

10 – New business.

11 – New meeting date & time.

12 – Adjournment.

ACI SUBCOMMITTEE 439-A MINUTES

May 22, 2008

To: Members of ACI Subcommittee 439-A

From: Theodore A. Mize, Chairman
Ivy Steel & Wire
815 Bethany Lane
Concord, CA 94518

Phone and Fax: 925-685-9141 Email: tamize@sbcglobal.net

Date: Sunday, March 30, 2008
Place: Century City, CA – Hyatt Regency Century Plaza – Penthouse 1923
Time: 3:30 – 5:00pm

1 – Meeting called to order by Chairman Mize at 3:30 P.M.

2 – Introduction and welcome guests and new members. 10 members and 1 visitor present.

3 – Approval of minutes from the Puerto Rico meeting (attached). Marvin made motion to approve, 2nd by Gallenz.

4 – Subcommittee membership update. Membership stands at 16 with no changes. Marvin noted that P. Ross and K. Williamson may drop their membership in the near future.

5 – Changes to ACI 318.

c. Material and use related changes in 318-08. Mize noted an increase in transverse reinforcement strength to 100 ksi. Also, the development and lap splice equations for plain wire and welded plain wire reinforcement are to be used for wire larger than D31. Marvin confirmed the change for the Class B splice that clarifies the minimum lap splice length is a function of the calculated development length and not the 12-inch minimum.
d. Proposed changes for 318-11. Changes to the maximum wire spacing of 16” on deformed WWR and 12” on plain WWR will be considered. The committee discussed whether to suggest changes to the code to include smaller than D4. Ramsey suggested making any necessary changes to the ASTM standards for raised rib deformed wire. Ramsey noted one manufacturer that does not produce smooth wire; he suggested that we survey WRI members for input at the next meeting. Ramsey made motion to discuss at the next WRI meeting, 2nd by DeValve.

6 – Discussion/report on proposed ACI Guide document. Marvin mentioned we have received feedback from TAC that will be discussed in the 439 meeting. The physical properties guide has been approved but we need to address their comments. We need to develop a list of keywords for the guide document. Suggested words are: welded wire reinforcement, weld shear, tensile strength, yield strength, ductility, deformed wire, plain wire, spiral wire, cold worked, line wire, cross wire, bending, resistance weld, W/D designations.

7 – Subcommittee review of implementation goals.

c. Discuss educational plan. Marvin noted that 439 hopes to sponsor a session on constructability in the future. We may consider joint sponsorship with E702 or 315. Mize and others suggested including topics such as splicing and development lengths in slabs, placing methods, beam/column intersections, post-tensioned elements, slab edge considerations, tilt-up concrete, and precast/prestressed/cast-in-place elements.
d. Discuss new ideas for subcommittee goals. We intend to sponsor a session on our guide document after it is published.

8 – Report on new or revised ASTM Standards. Mize reported that the proposed galvanized specification had a few negative votes that will be addressed at the next meeting. The welded grid standard also had several negatives. The combination standard for the 4 wire and WWR standards also had several negatives. None are believed to be insurmountable.

10 – New business. Lutz mentioned items pertaining to WWR that will be discussed tomorrow on the Materials and Properties document. He mentioned “stock” and “non-stock” issues regarding maximum/minimum/typical dimensions. Also, he mentioned quantity designations in tons and megagrams that will need to be addressed. Mize suggested a metric unit of metric tons. We will check with the AMM and see what metric units are used and conform to those.

11 – New meeting date & time. The same time slot will be requested, Sunday afternoon.

12 – Adjournment. Meeting adjourned at 5:07 P.M.

ACI 439.ZR-XX, "Comprehensive Guide for the Specification, Manufacture and Construction Use of Welded Wire Reinforcement"

Review Comments by Anthony Felder

General Comments:

1. Need to remove the promotional and "redesign-rebar-into-WWR" verbiage, which doesn't belong in a technical paper. Note such phrases as:

    "ease and speed"
    "considerably reduces placing time"
    "while not compromising customer satisfaction"
    "many contractors have realized the savings . . . in lieu of reinforcing bars"
    "as one can imagine . . . WWR greatly diminishes . . . conventional steel"
    "heavier reinforcement . . . can be converted to WWR"
    "conversion engineer"
    "converting to Welded Wire Reinforcement"
    "re-design into WWR"
    "appropriate conversion design to WWR"
    "better crack control"
    "reinforcement of choice"
    "superior crack control"
    "versatility that it allows"

2. Consider adding hard metric tables for deformed and plain wire, as shown in ASTM A82 and A496.
3. The title of the report refers to specification, manufacture and construction, which (I think) correlates to Chapters 2, 3, and 5, respectively. Hasn't the subject matter of Chapter 4 already been covered in the "Availability and Use" Committee report?

Specific Comments:

1. Section 1.1, third paragraph, first line. Remove "peak season".
2. Table 1b. Last four columns are labeled as "deformation requirements", but I'm not sure that applies to the first column (perimeter). Also, the second and third columns list the "maximum" and "minimum", but of what? The last column refers to a footnote (f), but it seems to be missing at the bottom of the Table.
3. Section 1.2, example. In three places, the deformed wire is identified as "Grade 80". ASTM A496 does not cover Grade 80 for deformed wire used in the manufacture of WWR, only Grade 70. Also, is it confusing to use "Var." as the variable for two different dimensions?
4. Sections 1.2.1, 1.2.2, and 1.2.3. References to "Figure 2" should be changed to "Figure 1".
5. Chapter 2 Introduction. There is a reference to "four" codes or specs "bodies", but only three organizations are listed.
6. Section 2.1. In the listing of the AASHTO specifications, it might be useful to list in parenthesis the matching ASTM specifications, to support the third sentence.
7. Section 2.2. I'm not sure how TAC will react to repeating verbatim sections of the 318 Code. Also, remember that Committee 318 is in the process of completely reformatting the 318 Code, so these excerpts will not be relevant with the next edition of 318.
8. Section 2.3. Not sure if ASTM A184 should be in your list.

9. Section 3.3. In second line, what is reference to “introduction of this manual”?
10. Section 3.5, second Part II (should be Part III). Not sure if this kind of detail is necessary for this report.
11. Section 4.1.2. A reference is made to “with the exception of seismic applications”. What is this exception? No WWR in high-seismic zones?
12. Section 4.1.3. There needs to be a bit of clarification made. The ACI Code does not “govern” “finger splices”. It does permit lap splices of deformed WWR without any cross wires. It does not permit such lap splices for plain WWR.
13. Section 4.2, first sentence. In first line, change “is the most widely” to “is a widely”. Also, would it be helpful to list those kinds of precast members where WWR is widely used?
14. Section 5.5. Need to clarify where “finger splices” are and are not permitted. See my Comment #12.

REVIEW OF DRAFT ACI 439.ZR-XX
DUE: 10-24-08 By David DeValve

Line 59-**Keywords: Welded Wire Reinforcement (WWR), Wire Reinforcement Institute (WRI), Specifications, Manufacturing, Applications, Cast-in-place, Precast, Prestressed, Post-tensioned, Concrete.**

In Table 1b- add the third decimal number in the unit weight column for the last three wire sizes (D30 @1.020, D31 @1.054, & D45@1.530) to be consistent with numbers above.

In the first paragraph on page 6 and a reference to Fig. 1 as that is what is described in the style description below.

On P. 8-change all 3 figure references to Fig. **1** from Fig. 2.

In Chapter 2- 1st paragraph **4 main code bodies are stated only three are listed.** Do we want to change it to the 3 listed or include a 4th (i.e., IBC or other that specifically references the others where it pertains to industry expertise)?

P. 20 last 2 paragraphs-rephrase what appears to be a duplicate discussion of stress and strain for wire between these paragraphs.

P. 30 line 1007-Ref. should be (see section **2.2**) & **line 1009** …ACI **318** code section 14….

P.36 line 1274 …are provide**d** by…; **line 1276** …splices (…) ~~**this**~~ provide~~**s**~~….; **line 1280** add an example reference to the end of the sentence- i.e. (example see section 2.2); **line 1299** remove . ~~5.2 FIELD WELDING~~ after the sentence.

P. 37 line 1332&1333-remove dated NPCA ref. ~~(accessed June 16, 2006)~~.
Line 1336 replace dated PCI ref. (same as above) with
…/projects/**index.cfm.**

William C. Gallenz

Subject: FW: Comprehensive Guide

----- Original Message -----
From: "Zehrt, William Mr DODESB" <william.zehrt@ddesb.osd.mil>
To: <mdm.tmg@comcast.net>
Sent: Friday, October 24, 2008 10:59 AM
Subject: RE: Comprehensive Guide

Good Morning, Mark - I hope all is well there.

I just reviewed the subject guide. Very good info. No comments from here.

By the way, I'm running into the same problem with FY 09 travel funds as I did last year. As a result, I'm afraid that I won't be able to make the fall convention/ACI 439 meeting. I will be at the spring meeting in San Antonio. Until then, please let me know if there's anything I can do to support the committee.

Thanks,

Bill

William C. Gallenz

Subject: FW: Welded Wire Reinforcement Guide

----- Original Message -----
From: "Fredrickson, Paul S" <Paul.Fredrickson@cmc.com>
To: <mdm.tmg@comcast.net>
Sent: Friday, October 24, 2008 6:27 PM
Subject: RE: Welded Wire Reinforcement Guide

Mark,

Sorry I have been "MIA" for the past several meetings but I had been assigned to a global computer project for CMC and simply could not afford the time to attend the conventions at the last minute, even though I had registered. At any rate following are a couple of general comments on the subject draft:

1) ACI 318 will be reformatted in the next cycle making all of the code references in this document invalid at that time. It doesn't seem prudent to include all of the references when we anticipate them being out of date within 5 - 6 years.

2) A lot of the language references the substitution of WWR for conventional reinforcement. I do not believe this will be well accepted by the committee or TAK.

3) We discuss 80ksi being allowed for WWR (and higher for prestressing steel). The code has been changed to allow this higher value for conventional reinforcement as well.

Hope this helps - see you in St Louis,

Paul

William C. Gallenz

Subject: FW: Fw: Comprehensive Guide
Attachments: 439.zr-xx-3-23-08_BPI-markup.doc

----- Original Message -----
From: Karen and Tim Cartwright
To: mdm.tmg@comcast.net
Cc: steveh@barsplice.com ; Tim@work ; tlcart_bpi@yahoo.com
Sent: Friday, October 24, 2008 5:57 PM
Subject: FW: Fw: Comprehensive Guide

Mr. Marvin,
Please see the attached file for my comments on the Comprehensive Guide for Welded Wire Reinforcement. Steve Holdsworth has requested that I review the report and send my comments to you. Also, I will be attending the next ACI Committee meeting in St. Louis as a proxy for Steve.

Best Regards,

Tim Cartwright
Engineering Manager
Barsplice Products, Inc.
4900 Webster St.
Dayton, OH 45414
937.275.8700 x191

------ Original Message ------
From: Steve Holdsworth <steveh@barsplice.com>
Date: Tuesday, October 7th, 2008 12:03 PM EDT
To: Tim Cartwright <tim@barsplice.com>
Subject: Fw: Comprehensive Guide

Tim,
I have downloaded and attached the Comprehensive Guide for Welded Wire Reinforcement that is referred to below. You will need to review this and send your comments to Mark Marvin no later than Friday, October 24, 2008. This will be be discussed at the ACI Fall Meeting that you are going to.

Steve Holdsworth
VP Operations / Technical Mgr.
Barsplice Products, Inc.
4900 Webster Street,
Dayton, OH 45414
Tel 939-275-8700 ext 192
Fax 937-275-9566
steveh@barsplice.com

Nominal Dimensions				Deformation Requirements			
Wire Size (a)	Unit Weight Lb/ft(kg/m)	Diameter in.(mm) (b)	Cross-sectional Area, in^2(mm2) (c)	Perimeter in.(mm)	Max. in.(mm)	Min. in.(mm)	Min. Avg. Height of Deformation in.(mm) (e), (f)
D-1	0.034 (0.051)	0.113 (2.87)	0.010 (6.45)	0.354 (9.00)	0.285 (7.24)	0.182 (4.62)	0.0045 (0.114)
D-2	0.068 (0.101)	0.160 (4.05)	0.020 (12.9)	0.501 (12.7)	0.285 (7.24)	0.182 (4.62)	0.0063 (0.160)
D-3	0.102 (0.152)	0.195 (4.96)	0.030 (19.4)	0.614 (15.6)	0.285 (7.24)	0.182 (4.62)	0.0078 (0.198)
D-4	0.136 (0.202)	0.226 (5.73)	0.040 (25.8)	0.709 (18.0)	0.285 (7.24)	0.182 (4.62)	0.0101 (0.257)
D-5	0.170 (0.253)	0.252 (6.41)	0.050 (32.3)	0.793 (20.1)	0.285 (7.24)	0.182 (4.62)	0.0113 (0.287)
D-6	0.204 (0.304)	0.276 (7.02)	0.060 (38.7)	0.868 (22.1)	0.285 (7.24)	0.182 (4.62)	0.0124 (0.315)
D-7	0.238 (0.354)	0.299 (7.58)	0.070 (45.2)	0.938 (23.8)	0.285 (7.24)	0.182 (4.62)	0.0134 (0.304)
D-8	0.272 (0.405)	0.319 (8.11)	0.080 (51.6)	1.00 (25.5)	0.285 (7.24)	0.182 (4.62)	0.0143 (0.363)
D-9	0.306 (0.455)	0.339 (8.60)	0.090 (58.1)	1.06 (27.0)	0.285 (7.24)	0.182 (4.62)	0.0152 (0.386)
D-10	0.340 (0.506)	0.357 (9.06)	0.100 (64.5)	1.12 (28.5)	0.285 (7.24)	0.182 (4.62)	0.0160 (0.406)
D-11	0.374 (0.557)	0.374 (9.51)	0.110 (71.0)	1.18 (29.9)	0.285 (7.24)	0.182 (4.62)	0.0187 (0.475)
D-12	0.408 (0.607)	0.391 (9.93)	0.120 (77.4)	1.23 (31.2)	0.285 (7.24)	0.182 (4.62)	0.0195 (0.495)
D-13	0.442 (0.658)	0.407 (10.3)	0.130 (83.9)	1.28 (32.5)	0.285 (7.24)	0.182 (4.62)	0.0203 (0.516)
D-14	0.476 (0.708)	0.422 (10.7)	0.140 (90.3)	1.33 (33.7)	0.285 (7.24)	0.182 (4.62)	0.0211 (0.536)
D-15	0.510 (0.759)	0.437 (11.1)	0.150 (96.8)	1.37 (34.9)	0.285 (7.24)	0.182 (4.62)	0.0218 (0.554)
D-16	0.544 (0.810)	0.451 (11.5)	0.160 (103)	1.42 (36.0)	0.285 (7.24)	0.182 (4.62)	0.0225(0.572)
D-17	0.578 (0.860)	0.465 (11.8)	0.170 (110)	1.46 (37.1)	0.285 (7.24)	0.182 (4.62)	0.0232 (0.589)
D-18	0.612 (0.911)	0.479 (12.2)	0.180 (116)	1.50 (38.2)	0.285 (7.24)	0.182 (4.62)	0.0239 (0.607)
D-19	0.646 (0.961)	0.492 (12.5)	0.190 (122)	1.55 (39.2)	0.285 (7.24)	0.182 (4.62)	0.0245 (0.622)
D-20	0.680 (1.01)	0.505 (12.8)	0.200 (129)	1.59 (40.3)	0.285 (7.24)	0.182 (4.62)	0.0252 (0.604)
D-21	0.714 (1.06)	0.517 (13.1)	0.210 (135)	1.62 (41.3)	0.285 (7.24)	0.182 (4.62)	0.0259 (0.658)
D-22	0.748 (1.11)	0.529 (13.4)	0.220 (141)	1.66 (42.2)	0.285 (7.24)	0.182 (4.62)	0.0265 (0.673)
D-23	0.782 (1.16)	0.541 (13.7)	0.230 (148)	1.70 (43.2)	0.285 (7.24)	0.182 (4.62)	0.0271 (0.688)
D-24	0.816 (1.21)	0.553 (14.0)	0.240 (154)	1.74 (44.1)	0.285 (7.24)	0.182 (4.62)	0.0277 (0.704)
D-25	0.850 (1.26)	0.564 (14.3)	0.250 (161)	1.77 (45.0)	0.285 (7.24)	0.182 (4.62)	0.0282 (0.716)
D-26	0.884 (1.32)	0.575 (14.6)	0.260 (167)	1.81 (45.9)	0.285 (7.24)	0.182 (4.62)	0.0288 (0.732)
D-27	0.918 (1.37)	0.586 (14.9)	0.270 (174)	1.84 (46.8)	0.285 (7.24)	0.182 (4.62)	0.0293 (0.744)
D-28	0.952 (1.42)	0.597 (15.2)	0.280 (180)	1.88 (47.6)	0.285 (7.24)	0.182 (4.62)	0.0299 (0.759)
D-29	0.986 (1.47)	0.608 (15.4)	0.290 (187)	1.91 (48.5)	0.285 (7.24)	0.182 (4.62)	0.0304 (0.772)
D-30	1.02 (1.52)	0.618 (15.7)	0.300 (193)	1.94 (49.3)	0.285 (7.24)	0.182 (4.62)	0.0309 (0.785)
D-31	1.05 (1.57)	0.628 (16.0)	0.310 (200)	1.97 (50.1)	0.285 (7.24)	0.182 (4.62)	0.0314 (0.798)
D-45	1.53 (2.28)	0.757 (19.2)	0.450 (290)	2.38 (60.4)	0.285 (7.24)	0.182 (4.62)	0.0379 (0.961)

Table 1b (Deformed Wire)

a. For sizes other than those shown above, the Size Number shall be the number of one hundredths of a square inch in the nominal area of the deformed wire cross-section, prefixed by the letter D

b. The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire

c. The cross-sectional area is based on the nominal diameter. The area in square inches may be calculated by dividing the unit weight in pounds by 0.2833 (weight of 1 in.3 of steel), or by dividing the unit weight per lineal foot of specimen in pounds by 3.4 (weight of steel 1 in. square and 1 foot long)

d. The minimum average height of the deformations shall be determined from measurements made on not less than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentation as described in 6.2.

e. These sizes represent the most readily available sizes in the Welded Wire Reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 0.0015 in2 (1 mm2) increments.

Comment [TC1]: What are these headers referring to?

Comment [TC2]: Footnote letters do not match up with the footnotes at the bottom of this table.

Comment [TC3]: Recommend making the 3 superscript. Also, make the 2 superscript in line 198 below.

Comment [TC4]: This conflicts with footnote a. above.

1.2 Product Description

Spacing and size of wire in WWR are identified by "style". The following subsections explain the orientation and definition of each part in the make-up of a WWR sheet. When the WWR sheet is designated for quotation or order entry it should be described as follows:

6 x 12 - D20.0 x D15.0 (Grade 80)
78"(+12, +6) x 20'-0"(24, 12)
263.53 Lbs./Sheet
150 Sheets Required

Where: 6 = spacing of longitudinal wires.
12 = spacing of transverse wires.
D20.0 = size and type (deformed or plain) of longitudinal wires.
D15.0 = size and type (deformed or plain) of transverse wires.
(Grade 80) = yield strength of specified wire sizes (ksi).
78"(+12, +6) x 20'-0"(24,12) = see sections 1.2.1 through 1.2.3.
263.53 Lbs./Sheet = see section 1.2.4.
150 Sheets Required = see section 1.2.5.

For sheets with variable wire spacing or variable length, the sheet should be described as follows:

~~Var.~~VL x ~~Var.~~VT - D20.0 x D15.0 (Grade 80)
78"(+12, +6) x Var. Length (24, 12)
L.S. = 12" OH, 1 @ 8", 7 @ 10", 6" OH
T.S. = 24" OH, 2 @ 6", 15 @ 12", 2@ 6", 12" OH
Var. Length = Alternate every other wire 20'-0", 15'-0", 20'-0" etc.
190.17 Lbs./Sheet
215 Sheets Required

Where: ~~Var.~~VL = variable spacing of longitudinal wires.
~~Var.~~VT = variable spacing of transverse wires.
D20.0 = size and type (deformed or plain) of longitudinal wires.
D15.0 = size and type (deformed or plain) of transverse wires.
(Grade 80) = yield strength of specified wire sizes (ksi).
78"(+12, +6) x Var. Length (24, 12) = see sections 1.2.1 through 1.2.3.
L.S. = description of variable longitudinal spacing.
T.S. = description of variable transverse spacing.
Var. Length = description of variable length. See section 1.2.2.
190.17 Lbs./Sheet = see section 1.2.4.
215 Sheets Required = see section 1.2.5.

1.2.5 Sheet Quantities

Sheet quantity is calculated by determining the total units required on a project and calculating the number of sheets per unit. For precast elements, sheet quantity per unit is multiplied by the total number of units for total sheet quantity. This quantity should always be listed on the line after the weight listing in the sheet style designation. For cast-in-place concrete, the total mass quantity (i.e.: square feet, linear feet) is divided by the total working dimension of the designed sheet. The working dimension of the WWR sheet is the total sheet square footage minus the end lap and the side lap in the same measurable units. This quantity would determine what is known as "lap waste". This quantity should always be listed on the line after the weight listing in the sheet style designation.

Chapter 2 - CODES AND STANDARDS

Introduction - There are four main code and/or specification bodies that govern the manufacture, testing and design of concrete applications as they pertain to reinforcement. The four main bodies that govern design and manufacturing are outlined below including the appropriate specification numbers and a description for interpretation purposes.

2.1 AASHTO

AASHTO (American Association of State Highway and Transportation Officials) specifications are the governing body for all transportation-related design and construction. This means that any public road project such as bridge decks, bridge beams, roadway or airport paving or state funded box culvert work would fall under the appropriate AASHTO specification. As is usually the case, many AASHTO sections refer to or mirror the ASTM specifications for manufacture and testing. The specifications governing Welded Wire Reinforcement and the description of their meaning are as follows:

M31 - Deformed and plain Billet-Steel Bars for Concrete Reinforcement
M32 - Cold-Drawn Steel Wire for Concrete Reinforcement
M55 - Welded Steel Wire Fabric for Concrete Reinforcement
M42 - Deformed and Plain Rail – Steel Bars for Concrete Reinforcement
M221 - Welded Deformed Steel Wire Fabric For Concrete Reinforcement
M225 - Deformed Steel Wire for Concrete Reinforcement

2.2 ACI

The ACI 318 (American Concrete Institute) Building Code Requirements for Structural Concrete is the governing code, specification and design guide for all structural concrete design in the United States of America. This code provides guidelines for testing and design as well as construction and placement. Although an engineer should be well versed in every aspect of the 318 code, the following sections are the most critical as they apply to concrete design using Welded Wire Reinforcement.

Comment [TC5]: Redundant, suggest removing.

PROVISION	ACI 318 SECTION
A. Definitions	
1. Deformed reinforcement — Deformed reinforcing bars, bar mats, deformed wire, and welded wire reinforcement conforming to 3.5.3.	**2.2**
B. Standards for Tests and Materials	
1. Bar mats for concrete reinforcement shall conform to "Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement" (ASTM A 184). Reinforcing bars used in bar mats shall conform to ASTM A 615 or A 706.	**3.5.3.3**
2. Deformed wire for concrete reinforcement shall conform to "Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement" (ASTM A 496), except that wire shall not be smaller than size D4 and for wire with f_y exceeding 60,000 psi, the yield strength shall be taken as the stress corresponding to a strain of 0.35 percent.	**3.5.3.4**
3. Welded plain wire reinforcement shall conform to "Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete" (ASTM A 185), except that for wire with f_y exceeding 60,000 psi, the yield strength shall be taken as the stress corresponding to a strain of 0.35 percent. Welded intersections shall not be spaced farther apart than 12 in. in direction of calculated stress, except for welded wire reinforcement used as stirrups in accordance with 12.13.2.	**3.5.3.5**
4. Welded deformed wire reinforcement shall conform to "Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete" (ASTM A 497), except that for wire with f_y exceeding 60,000 psi, the yield strength shall be taken as the stress corresponding to a strain of 0.35 percent. Welded intersections shall not be spaced farther apart than 16 in. in direction of calculated stress, except for welded deformed wire reinforcement used as stirrups in accordance with 12.13.2.	**3.5.3.6**
5. Epoxy-coated wires and welded wire reinforcement shall comply with "Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement" (ASTM A 884). Wires to be epoxy coated shall conform to 3.5.3.4 and welded wire reinforcement to be epoxy-coated shall conform to 3.5.3.5 or 3.5.3.6.	**3.5.3.8**

PROVISION	ACI 318 SECTION
C. Details of Reinforcement	
1. The term standard hook as used in this code shall mean one of the following:	**7.1**
2. 180-deg bend plus **4*d*b** extension, but not less than 2-1/2 in. at free end of bar.	**7.1.1**
3. 90-deg bend plus **12*d*b** extension at free end of bar.	**7.1.2**
4. Inside diameter of bend in welded wire reinforcement for stirrups and ties shall not be less than **4*d*b** for deformed wire larger than D6 and **2*d*b** for all other wires. Bends with inside diameter of less than **8*d*b** shall not be less than **4*d*b** from nearest welded intersection.	**7.2.3**
5. All reinforcement shall be bent cold, unless otherwise permitted by the engineer.	**7.3.1**
6. Reinforcement partially embedded in concrete shall not be field bent, except as shown on the design drawings or permitted by the engineer.	**7.3.2**
7. Welded wire reinforcement (with wire size not greater than W5 or D5) used in slabs not exceeding 10 ft in span shall be permitted to be curved from a point near the top of slab over the support to a point near the bottom of slab at midspan, provided such reinforcement is either continuous over, or securely anchored at support.	**7.5.3**
8. Welding of crossing bars shall not be permitted for assembly of reinforcement unless authorized by the engineer.	**7.5.4 plus commentary**
9. It shall be permitted to waive the lateral reinforcement requirements of 7.10, 10.16, and 18.11 where tests and structural analysis show adequate strength and feasibility of construction.	**7.10.3 plus commentary**
10. Spiral reinforcement for compression members shall conform to 10.9.3 and to the following:	
11. Spirals shall consist of evenly spaced continuous bar or wire of such size and so assembled to permit handling and placing without distortion from designed dimensions.	**7.10.4 plus commentary** **7.10.4.1**

	PROVISION	ACI 318 SECTION
C. Details of Reinforcement (cont.)		
1.	Spiral reinforcement shall be spliced, if needed, by any one of the following methods: (a) Lap splices not less than the larger of 12 in. and the length indicated in one of (1) through (5) below: (1) deformed uncoated bar or wire..... **$48d_b$** (2) plain uncoated bar or wire ..... **$72d_b$** (3) epoxy-coated deformed bar or wire ... **$72d_b$** (4) plain uncoated bar or wire with a standard stirrup or tie hook in accordance with 7.1.3 at ends of lapped spiral reinforcement. The hooks shall be embedded within the core confined by the spiral reinforcement ..... **$48d_b$** (5)epoxy-coated deformed bar or wire with a standard stirrup or tie hook in accordance wit h 7.1.3 at ends of lapped spiral reinforcement. The hooks shall be embedded within the core confined by the spiral reinforcement..... **$48d_b$**	**7.10.4.5**
2.	Compression reinforcement in beams shall be enclosed by ties or stirrups satisfying the size and spacing limitations in 7.10.5 or by welded wire reinforcement of equivalent area. Such ties or stirrups shall be provided throughout the distance where compression reinforcement is required.	**7.11.1**
3.	Reinforcement for shrinkage and temperature stresses normal to flexural reinforcement shall be provided in structural slabs where the flexural reinforcement extends in one direction only.	**7.12.1**
4.	Shrinkage and temperature reinforcement shall be provided in accordance with either 7.12.2 or 7.12.3.	**7.12.1.1**
5.	Where shrinkage and temperature movements are significantly restrained, the requirements of 8.2.4 and 9.2.3 shall be considered.	**7.12.1.2**
6.	Deformed reinforcement conforming to 3.5.3 used for shrinkage and temperature reinforcement shall be provided in accordance with the following:	**7.12.2**

PROVISION	ACI 318 SECTION
~~F.~~G. **Development and Splices of Reinforcement**	
1. Development length for deformed bars and deformed wire in tension, l_d shall be determined from either 12.2.2 or 12.2.3, but shall not be less than 12 in.	**12.2.1 plus commentary**
2. For deformed bars or deformed wire, l_d shall be: see table	**12.2.2**
3. For deformed bars or deformed wire, l_d shall be: $l_d = (3/40 \times f_y/\sqrt{f'_c} \times \psi_t \psi_e \psi_s \lambda / (c_b + K_{tr})/d_b)\, d_b$ (12-1) in which the term $(c_b + K_{tr})/d_b$ shall not be taken greater than 2.5, and $K_{tr} = A_{tr} f_{yt} / 1500sn$ (12-2) where n is the number of bars or wires being spliced or developed along the plane of splitting. It shall be permitted to use $K_{tr} = 0$ as a design simplification even if transverse reinforcement is present.	**12.2.3 plus commentary**
4. The factors used in the expressions for development of deformed bars and deformed wires in tension in 12.2 are as follows: (a) Where horizontal reinforcement is placed such that more than 12 in. of fresh concrete is cast below the development length or splice, $\psi_t = 1.3$. For other situations, $\psi_t = 1.0$. (b) For epoxy-coated bars or wires with cover less than $3d_b$, or clear spacing less than $6d_b$, $\psi_e = 1.5$. For all other epoxy-coated bars or wires, $\psi_e = 1.2$. For uncoated reinforcement, $\psi_e = 1.0$. However, the product $\psi_t \psi_e$ need not be greater than 1.7. (c) For No. 6 and smaller bars and deformed wires, $\psi_s = 0.8$. For No. 7 and larger bars, $\psi_s = 1.0$. (d) Where lightweight concrete is used, $\lambda = 1.3$. However, when f_{ct} is specified, λ shall be permitted to be taken as $6.7/\sqrt{f'_c}/f_{ct}$ but not less than 1.0. Where normal weight concrete is used, $\lambda = 1.0$	**12.2.4 plus commentary**

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PROVISION	ACI 318 SECTION
G. Development and Splices of Reinforcement (cont.)	
1. Development length in tension for welded deformed wire reinforcement, l_d, measured from the point of critical section to the end of wire shall be computed as the product of l_d, from 12.2.2 or 12.2.3, times a welded wire reinforcement factor from 12.7.2 or 12.7.3. It shall be permitted to reduce l_d in accordance with 12.2.5 when applicable, but l_d shall not be less than 8 in. except in computation of lap splices by 12.18. When using the welded wire reinforcement factor from 12.7.2, it shall be permitted to use an epoxy coating factor ψ_e of 1.0 for epoxy-coated welded wire reinforcement in 12.2.2 and 12.2.3.	**12.7.1 plus commentary**
2. For welded deformed wire reinforcement with at least one cross wire within l_d and not less than 2 in. from the point of the critical section, the welded wire reinforcement factor shall be the greater of: $f_y - 35{,}000 / f_y$ and $5 d_b / s$ but not greater than 1.0, where s is the spacing between the wires to be developed.	**12.7.2 plus commentary**
3. For welded deformed wire reinforcement with no cross wires within l_d or with a single cross wire less than 2 in. from the point of the critical section, the welded wire reinforcement factor shall be taken as 1.0, and l_d shall be determined as for deformed wire.	**12.7.3 plus commentary**
4. When any plain wires are present in the welded deformed wire reinforcement in the direction of the development length, the reinforcement shall be developed in accordance with 12.8.	**12.7.4 plus commentary**
5. Yield strength of welded plain wire reinforcement shall be considered developed by embedment of two cross wires with the closer cross wire not less than 2 in. from the point of the critical section. However, l_d shall not be less than $l_d = 0.27 \times A_b / s (f_y / \sqrt{f_c'}) \lambda$ (12-3) where l_d is measured from the point of the critical section to the outermost crosswire, and s is the spacing between the wires to be developed. Where reinforcement provided is in excess of that required, l_d may be reduced in accordance with 12.2.5. Length, l_d, shall not be less than 6 in. except in computation of lap splices by 12.19.	**12.8 plus commentary**

PROVISION	ACI 318 SECTION
H. Two-Way Slab Systems (cont.)	
1. Spacing of reinforcement at critical sections shall not exceed two times the slab thickness, except for portions of slab area of cellular or ribbed construction. In the slab over cellular spaces, reinforcement shall be provided as required by 7.12	**13.3.2 plus commentary**
I. Walls	
1. Minimum vertical and horizontal reinforcement shall be in accordance with 14.3.2 and 14.3.3 unless a greater amount is required for shear by 11.10.8 and 11.10.9.	**14.3.1 plus commentary**
2. Minimum ratio of vertical reinforcement area to gross concrete area, ρ_l, shall be: (a) 0.0012 for deformed bars not larger than No. 5 with f_y not less than 60,000 psi; or (b) 0.0015 for other deformed bars; or (c) 0.0012 for welded wire reinforcement not larger than W31 or D31.	**14.3.2**
3. Minimum ratio of horizontal reinforcement area to gross concrete area, ρ_t, shall be: (a) 0.0020 for deformed bars not larger than No. 5 with f_y not less than 60,000 psi; or (b) 0.0025 for other deformed bars; or (c) 0.0020 for welded wire reinforcement not larger than W31 or D31.	**14.3.3**
4. Walls more than 10 in. thick, except basement walls, shall have reinforcement for each direction placed in two layers parallel with faces of wall in accordance with the following: (a) One layer consisting of not less than one-half and not more than two-thirds of total reinforcement required for each direction shall be placed not less than 2 in. nor more than one-third the thickness of wall from the exterior surface; (b) The other layer, consisting of the balance of required reinforcement in that direction, shall be placed not less than 3/4 in. nor more than one-third the thickness of wall from the interior surface.	**14.3.4**
5. Vertical and horizontal reinforcement shall not be spaced farther apart than three times the wall thickness, nor farther apart than 18 in.	**14.3.5**
6. Vertical reinforcement need not be enclosed by lateral ties if vertical reinforcement area is not greater than 0.01 times gross concrete area, or where vertical reinforcement is not required as compression reinforcement.	**14.3.6**

curve for Wire B, also in Fig. 2, which is for a wire rolled from the same rod but with a smaller finished diameter. Wire C has a still larger amount of cold work and so the effect is even greater.

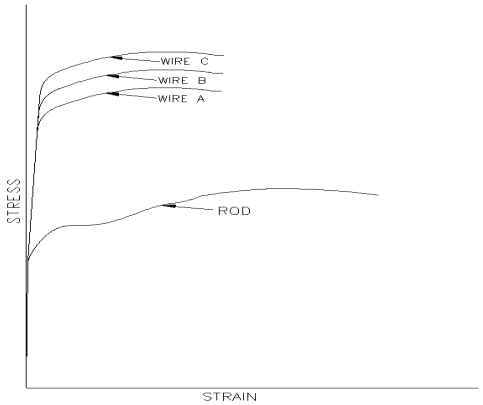

FIG. 2 IDEALIZED STRESS–STRAIN CURVES FOR HOT–ROLLED ROD AND COLD–ROLLED WIRE

From observations of this it may be stated that the physical characteristics of a wire are functions of two things: the chemistry of the rod and the amount of cold work done in rolling the wire. Wires are made in many sizes but rods are available in a limited number of diameters. Therefore, several different wire sizes are manufactured from one rod size

Although there is no true yield point for cold-worked wire, the yield point concept is so critical in structural analysis that an equivalent or substitute value is employed. This is generally stated as the stress at some specified elongation. According to the ASTM specifications governing the manufacture of reinforcing wire, the yield strength is arbitrarily fixed as the stress at which the total strain is .5% (0.005) for wire tested to 70,000 psi or below. For specified yield strengths exceeding 60,000 psi, the stress to strain correlation is set by ACI at .35% (.0035).

The American Concrete Institute (ACI) “Building Code Requirements for Reinforced Concrete” (ACI 318) specifically states that if a yield strength in excess of 60,000 psi is used for design of concrete structures it must not exceed the stress at which the total strain is .35% (.0035). This comes from the fact that the ultimate strain of concrete has been found to be between .3% and .4%. If steel and concrete are bonded together the strain in the former must be allowed to exceed the strain of the latter if the two are to function as a composite material. This is known as strain compatibility. This said, it is vital that when specifying WWR for concrete structures a definitive yield strength must be specified to the factory to assure proper design requirements and testing procedures are followed.

Chapter 6 - REFERENCES

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1.1 ASTM International, ASTM A 82 *Standard Specification for Steel Wire, Plain, for Concrete Reinforcement*, Table 5&6.
1.2 ASTM International, ASTM A 496 *Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement*, Table 1&2.

References, Chapter 3
3.1 ASTM International, ASTM A 496 *Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement*, Supplementary Requirements S1 and ACI 318 3.5.3.4 to 3.5.3.6 and 3.8.1

References, Chapter 4
4.1 American Concrete Institute, *ACI 318 Building Code Requirements for Structural Concrete and Commentary*, Chapter 12

4.2 National Precast Concrete Associations, *Specifiers, Precast Products*, National Precast Concrete Associations, http://www.precast.org/specifiers/precast_products.htm (accessed June 16, 2006).

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5.2 Wire Reinforcement Institute, WWR-500: *Manual of Standard Practice-Structural Welded Wire Reinforcement*. Chapters 5 and 6. http://www.wirereinforcementinstitute.org/HTDocs/Pages/WWR500.

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