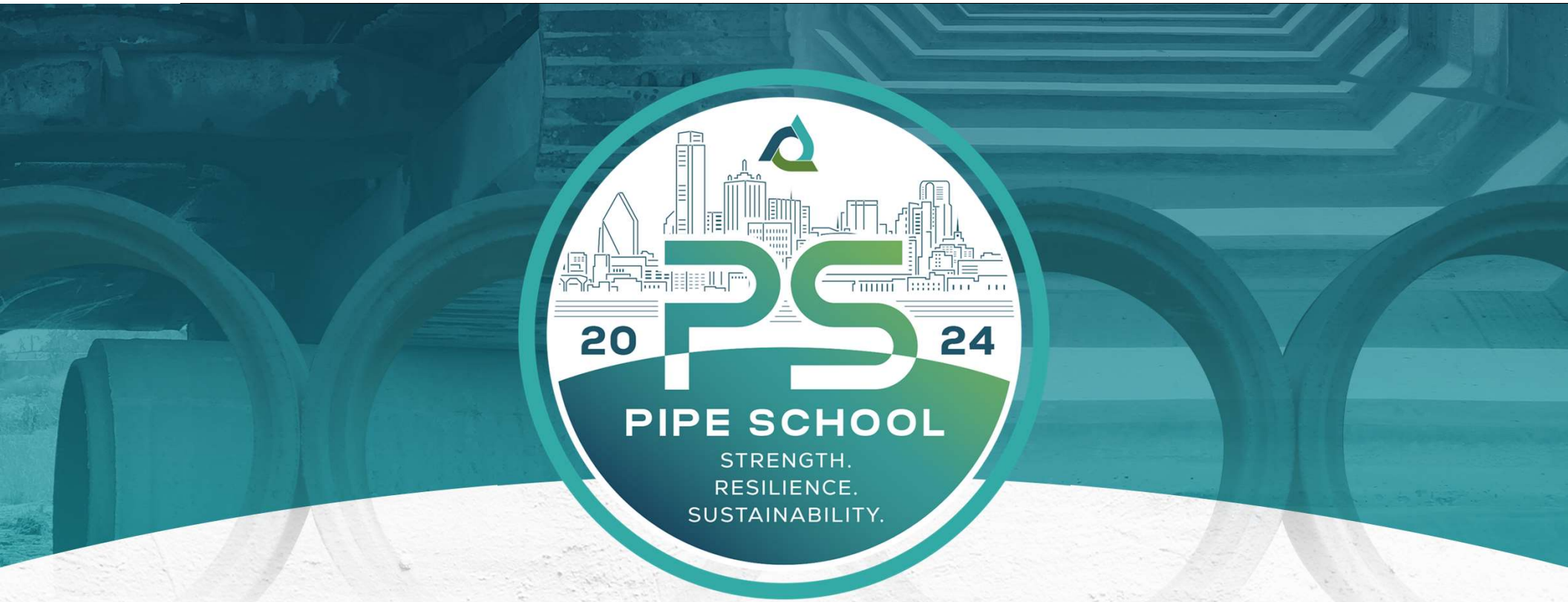


Reinforcement 2

Jake Jyrkama, P.E.

Rinker Materials

Concrete Pipe Design

Structural Design

- Indirect (D-Load) – (ACPA DD-9)
  Designed for concentrated load (3-Edge Bearing Test) that will produce the same bending moments as in the field

- Direct Design
  Designed for the anticipated soil pressures using typical ultimate strength design methodology

Concrete Pipe Strength (ASTM C76/AASHTO M170)

D-Load

Supporting strength of a pipe loaded under three-edge-bearing test conditions

Expressed in pounds per linear foot per foot of inside diameter or horizontal span

ASTM C 76 Class IV

$D_{0.01}$ = 2,000

D_{ULT} = 3,000

ASTM C76

D-Load

	0.01”D	Ult. D
Class I	800	1200
Class II	1000	1500
Class III	1350	2000
Class IV	2000	3000
Class V	3000	3750

D-Load Strength Determination

48” Profile Class IV 8’

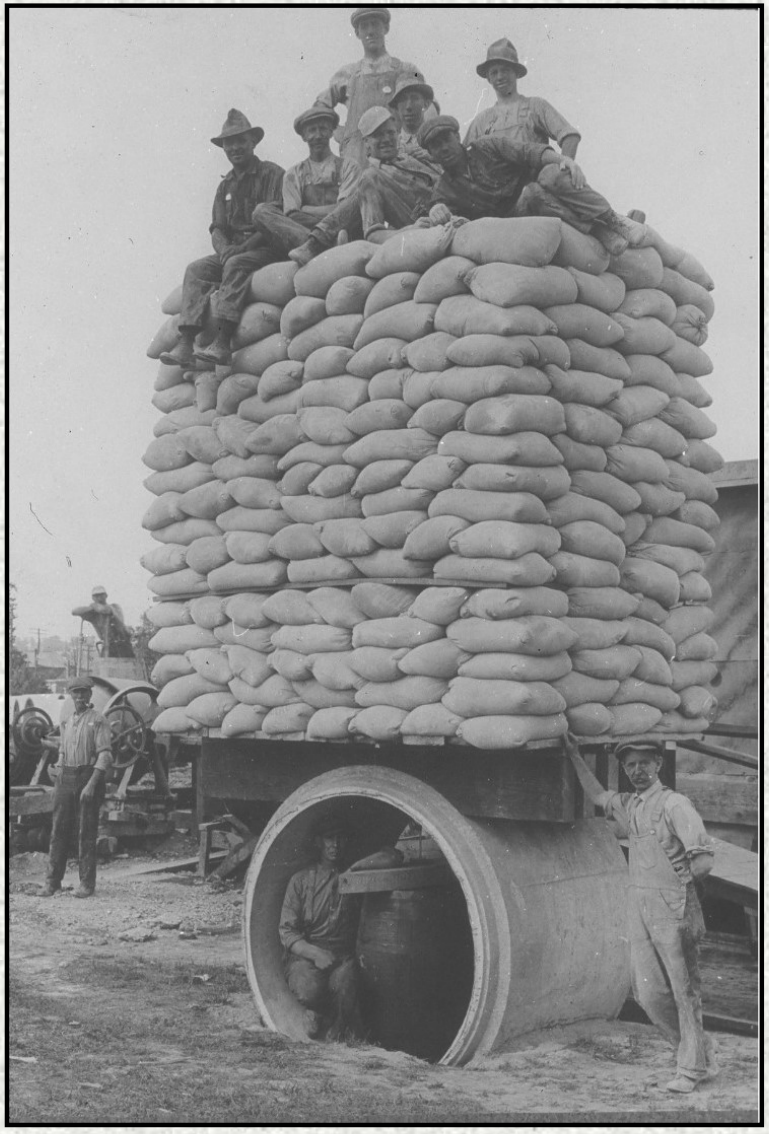
$D_{0.01}$ = 2000

D_{ULT} = 3000

Total Load Required:

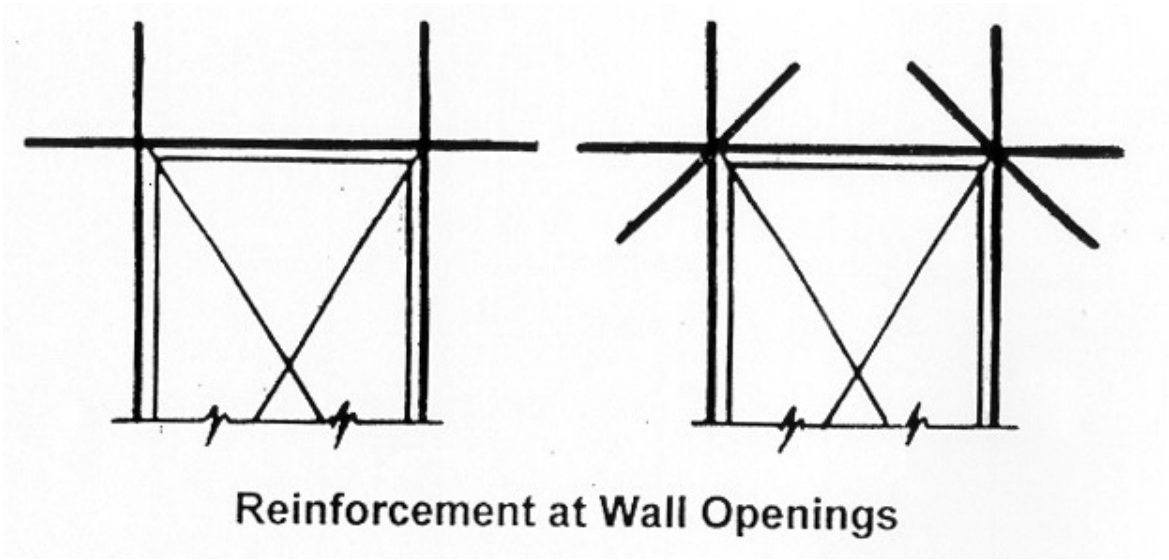
$D_{0.01}$ = (48/12)(8)(2000) = 64,000 lbs

D_{ULT} = (48/12)(8)(3000) = 96,000 lbs



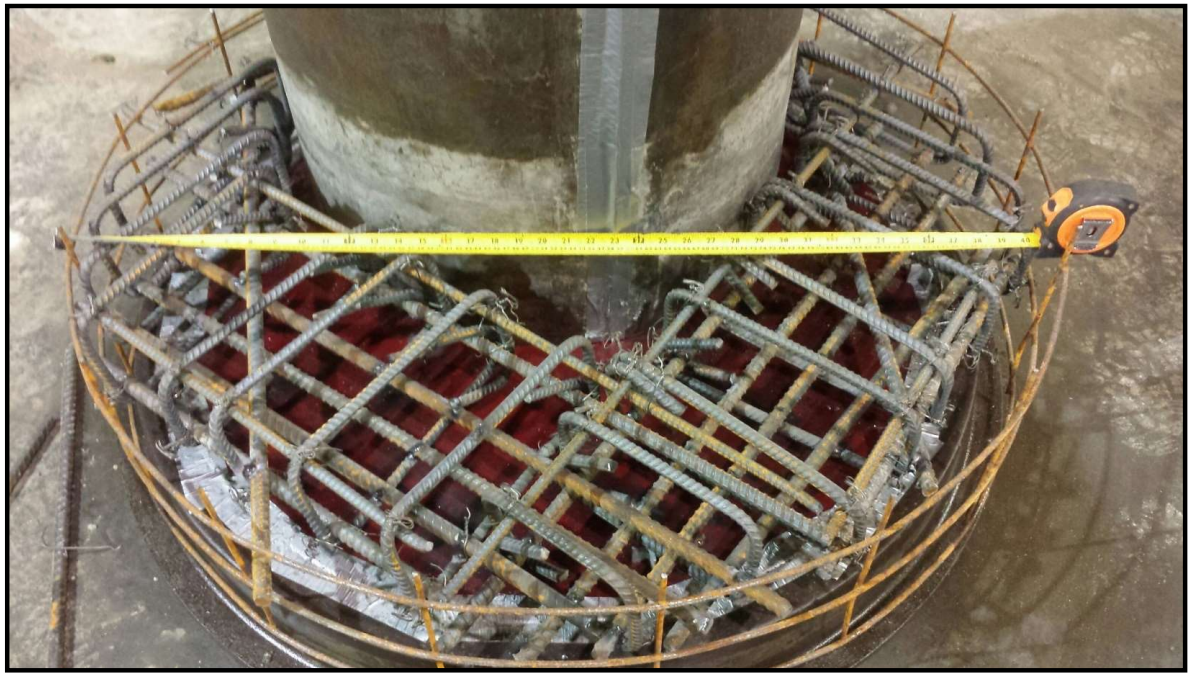

A2

Positioning Reinforcement



Reinforcement at Wall Openings

Positioning Reinforcement



Welding

Welding Requirements

Welding of reinforcement

- Maintain product integrity
- Two weldability limits
  - Max. Carbon content (0.30%) [AWS D1.4]
  - Carbon equivalent (CE)
- ACI 318 And AWS D1.4, CE are:
  - For #6 And smaller - 0.55%
  - For #7 And larger - 0.45%
- The lower The CE, The better The weldability
- For larger CE values, The rebar must be preheated

ASTM A615 Reinforcement

ASTM A615 rebar

- Must be used with extreme caution
- Generally not acceptable
- Check CE = %C + %Mn / 6

SOLD TO: [redacted]

NUCOR STEEL SEATTLE, INC.

CERTIFIED MILL TEST REPORT

Ship from: [redacted]

SHIP TO: [redacted]

Date: 30-Apr-2008
B.L. Number: 359150
Load Number: 205372

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 December 4, 2007

HEAT NUM. *	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	ROB - MAR,APR,MAY												
SE0810110105	Nucor Steel Seattle, Inc.	95,930	129,680	9.4%	OK	-4.8%	.33	1.30	.019	.043	.23	.44	.56
	19/#6 Rebar 20'	661MPa	894MPa			.055	.09	.11	.020	.143	.003		
	A615M Gr 420 (Gr60)												
	ASTM A615/A615M-08 GR 60[420]												
PO# =>	JULY-SEPT TONS												
SE0810163201	Nucor Steel Seattle, Inc.	70,181	110,090	16.4%	OK	-1.6%	.42	.65	.018	.029	.20	.32	.55
	10/#3 Rebar 20'	484MPa	759MPa			.029	.10	.13	.030	.006	.012		
	A615M GR 420 (Gr60)												
	ASTM A615/A615M-08 GR 60[420]												
PO# =>	JULY-SEPT TONS												
SE0810163301	Nucor Steel Seattle, Inc.	67,090	106,409	15.6%	OK		.41	.63	.015	.036	.20	.34	.54
	10/#3 Rebar 20'	463MPa	734MPa			.026	.10	.12	.020	.005	.012		
	A615M GR 420 (Gr60)												
	ASTM A615/A615M-08 GR 60[420]												
PO# =>	ROB - MAR,APR,MAY												
SE0810168101	Nucor Steel Seattle, Inc.	68,838	95,978	14.8%	OK	-4.6%	.40	.70	.016	.046	.19	.37	.54
	16/#5 Rebar 20'	475MPa	662MPa			.046	.12	.14	.030	.005	.016		
	A615M Gr 420 (Gr60)												
	ASTM A615/A615M-08 GR 60[420]												
PO# =>	ROB - MAR,APR,MAY												
SE0810168203	Nucor Steel Seattle, Inc.	68,770	92,910	15.6%	OK	-3.8%	.28	.77	.015	.034	.21	.39	.43
	19/#6 Rebar 20'	474MPa	641MPa			.048	.14	.12	.040	.035	.004		
	A615M Gr 420 (Gr60)												
	ASTM A615/A615M-08 GR 60[420]												

All steel products produced at Nucor Steel Seattle
are manufactured with over 98% recycled materials.

I HEREBY CERTIFY THAT THE ABOVE FIGURES ARE CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION.

ALL MANUFACTURING PROCESSES OF THE STEEL MATERIALS IN THIS PRODUCT, INCLUDING MELTING, HAVE OCCURRED WITHIN THE UNITED STATES. ALL PRODUCTS PRODUCED ARE WELD FREE. MERCURY, IN ANY FORM, HAS NOT BEEN USED IN THE PRODUCTION OR TESTING OF THIS MATERIAL.

QUALITY ASSURANCE: [redacted]

ASTM A706 Reinforcement

ASTM A706 rebar

- Is a low-alloy weldable grade
- Check CE =

%C + %Mn/6 + %Cu/40 + %Ni/20 + %Cr/10 - %Mo/50 - %V/10

SOLD TO: [redacted]

CERTIFIED MILL TEST REPORT

NUCOR STEEL SEATTLE, INC.

Ship from: [redacted]

206-933-2222

SHIP TO: [redacted]

Date: 29-Jul-2008
B.L. Number: 363694
Load Number: 209828

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 May 16, 2008

HEAT NUM. *	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS							
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	9297												
SE0810245201	Nucor Steel Seattle, Inc. 16/#5 Rebar 20' A706M (A706) ASTM A706/A706M-06a TEN/YD = 1.49	65,096 449MPa	96,818 668MPa	18.0%	OK	-3.6% .049	.26 .11	.76 .10	.014 .030	.042 .037	.19 .003	.37	.41
PO# =>	9297												
SE0810276301	Nucor Steel Seattle, Inc. 13/#4 Rebar 20' A706M (A706) ASTM A706/A706M-06a TEN/YD = 1.33	66,237 457MPa	88,094 607MPa	16.4%	OK	-4.2% .038	.28 .11	.74 .10	.012 .030	.041 .032	.21 .003	.35	.42
PO# =>	july,aug,sept												
SE0810386702	Nucor Steel Seattle, Inc. 19/#6 Rebar 20' A615M Gr 420 (Gr60) ASTM A615/A615M-08 GR 60[420]	65,034 448MPa	105,911 730MPa	14.1%	OK	-5.1% .049	.46 .09	.86 .07	.010 .020	.032 .005	.19 .019	.34	.62

I HEREBY CERTIFY THAT THE ABOVE FIGURES ARE CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION.

ALL MANUFACTURING PROCESSES OF THE STEEL MATERIALS IN THIS PRODUCT, INCLUDING MELTING, HAVE OCCURRED WITHIN THE UNITED STATES. ALL PRODUCTS PRODUCED ARE WELD FREE. MERCURY, IN ANY FORM, HAS NOT BEEN USED IN THE PRODUCTION OR TESTING OF THIS MATERIAL.

QUALITY ASSURANCE: [redacted] Winky Lai

Arc Welding

AWS D1.4

Table 5.2
Minimum Preheat and Interpass Temperatures[1], [2] (see 5.2.1)

Carbon Equivalent (C.E.) Range, %[3], [4]	Size of Reinforcing Bar	SMAW with Low-Hydrogen Electrodes, GMAW, or FCAW — Minimum Temperature °F	SMAW with Low-Hydrogen Electrodes, GMAW, or FCAW — Minimum Temperature °C
Up to 0.40	Up to 11 [36] inclusive	none[5]	none[5]
	14 and 18 [43 and 57]	50	10
Over 0.40 to 0.45 inclusive	Up to 11 [36] inclusive	none[5]	none[5]
	14 and 18 [43 and 57]	50	10
Over 0.45 to 0.55 inclusive	Up to 6 [19] inclusive	none[5]	none[5]
	7 to 11 [22 to 36]	50	10
	14 to 18 [43 to 57]	200	90
Over 0.55 to 0.65 inclusive	Up to 6 [19] inclusive	100	40
	7 to 11 [22 to 36]	200	90
	14 to 18 [43 to 57]	300	150
Over 0.65 to 0.75	Up to 6 [19] inclusive	300	150
	7 to 18 [22 to 57] inclusive	400	200
Over 0.75	Up to 6 [19] inclusive	300	150
	7 to 18 [22 to 57] inclusive	500	260

Notes:
(1) When reinforcing steel is to be welded to main carbon steel, the preheat requirements of the structural steel shall also be considered (see AWS D1.1, table titled "Prequalified Minimum Preheat and Interpass Temperature.") The minimum preheat requirement to apply in this situation shall be the higher requirement of the two tables. However, extreme caution shall be exercised in the case of welding reinforcing steel to quenched and tempered steels, and such measures shall be taken as to satisfy the preheat requirements for both. If not possible, welding shall not be used to join the two base metals.
(2) Welding shall not be done when the ambient temperature is lower than 0°F [–18°C]. When the base metal is below the temperature listed for the welding process being used and the size and carbon equivalent range of the bar being welded, it shall be preheated (except as otherwise provided) in such a manner that the cross section of the bar for not less than 6 in. [150 mm] on each side of the joint shall be at or above the specified minimum temperature. Preheat and interpass temperatures shall be sufficient to prevent crack formation.
(3) After welding is complete, bars shall be allowed to cool naturally to ambient temperature. Accelerated cooling is prohibited.
(4) Where it is impractical to obtain chemical analysis, the carbon equivalent shall be assumed to be above 0.75%. See also 1.3.4.3.
(5) When the base metal is below 32°F [0°C], the base metal shall be preheated to at least 70°F [20°C], or above, and maintained at this minimum temperature during welding.

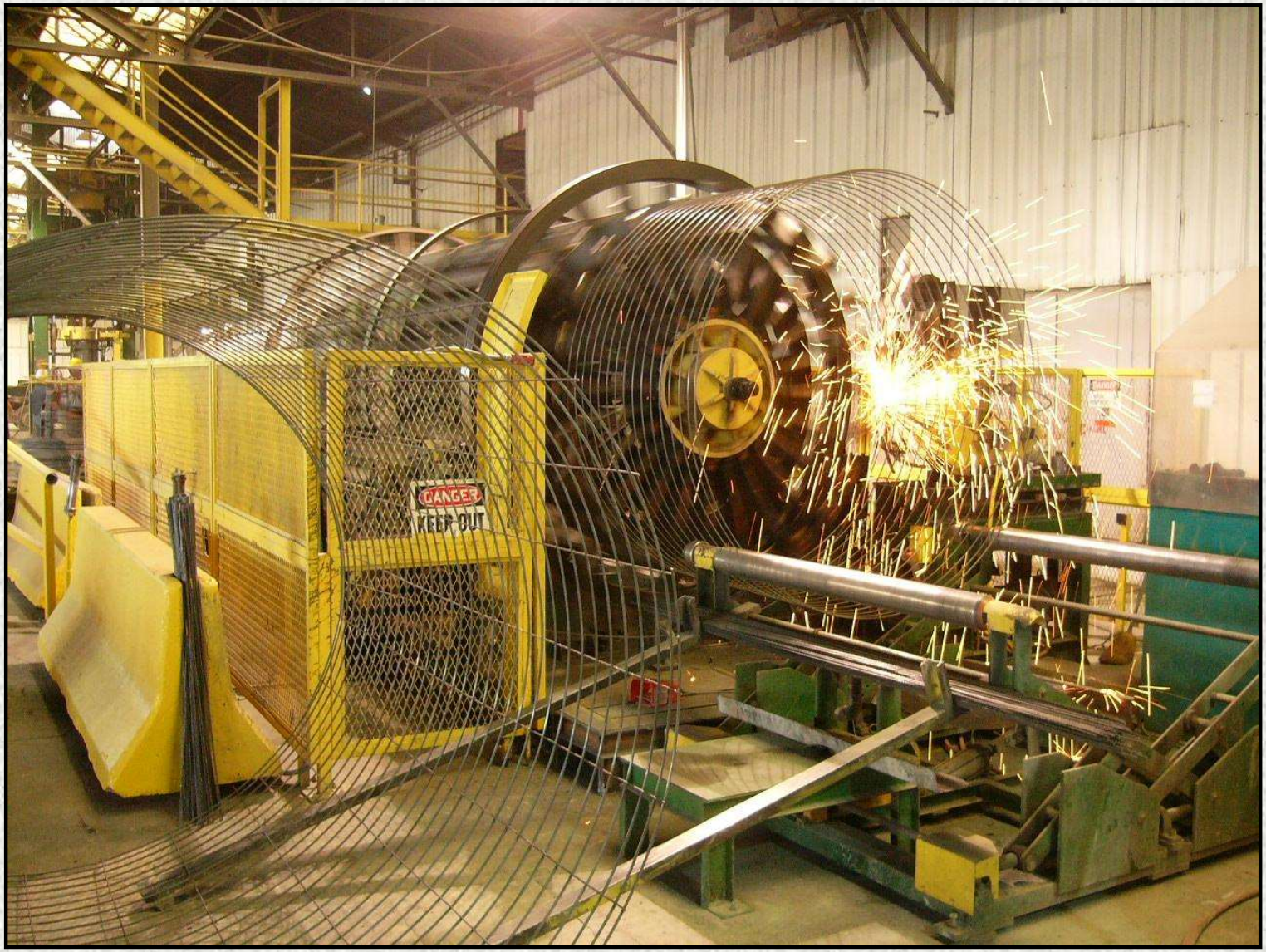
Pre-Heating Guidelines

If the chemical compositions of the rebars are not known, the following preheat guidelines are offered by ANSI/AWS D1.4.

1. For bars number 6 or less, use a minimum preheat of 300°F
2. For bars number 7 or larger, use a minimum preheat of 400°F
3. For all ASTM A706 bars sizes, use tabulated values for CE values of "over 0.45% to 0.55% inclusive."

Fabrication


AUTHORIZED
PERSONNEL
ONLY


DANGER
KEEP OUT

ACI 318 – Details of Reinforcement

- Standard Hooks
- Minimum Bend Diameters

Minimum Bend Diameters – ACI 318

Bar Size	Minimum Diameter
No.3 - No.8	$6d_b$
No.9, No.10, No.11	$8d_b$
No.14 and No.18	$10d_b$

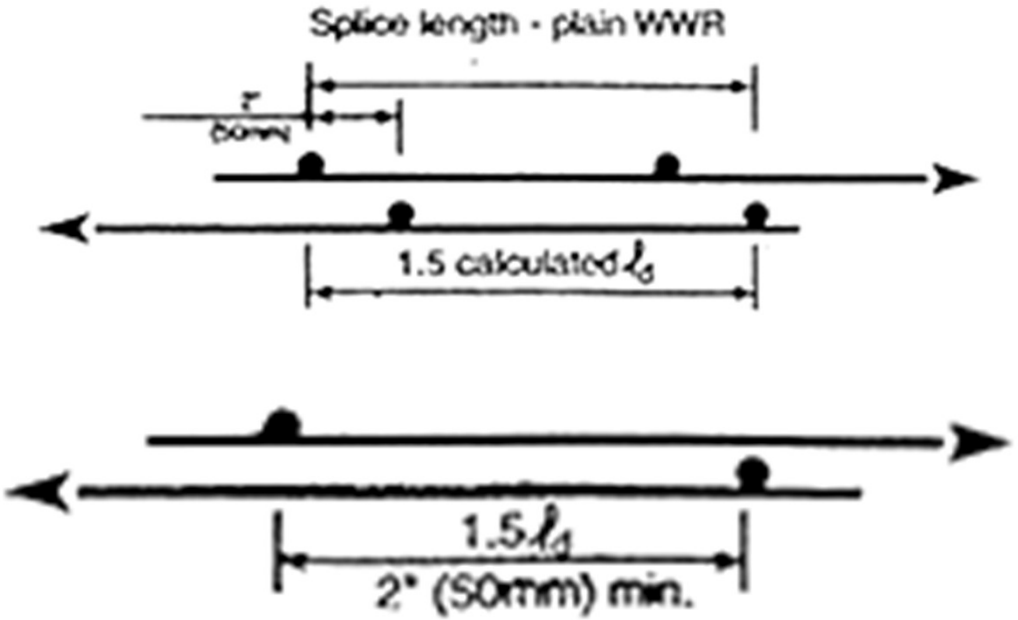
d_b = diameter of the bar
Not for Hooks or Stirrups


MENS
WASHROOM
R.M.S

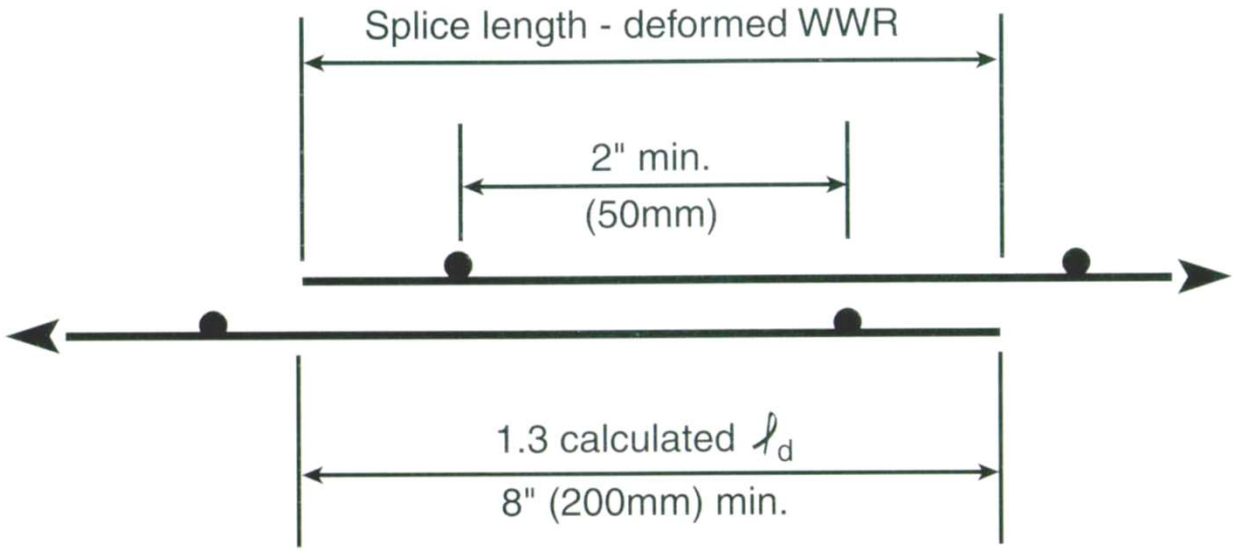
Minimum Bend Diameters – ASTM A1064

- All bends described in terms of inside diameter
- Factors affecting minimum bend diameters
  - Feasibility of bending without breaking
  - Avoidance of concrete crushing inside the bend
- Welded wire fabric
  - W7 and smaller $1d_b$
  - Larger than W7 $2d_b$
  - D6 and smaller $2d_b$
  - Larger than D6 $4d_b$

Plain Wire Splice Length – ACI 318



Deformed Wire Splice Length – ACI 318



Specifications

ASTM C76

- Section 7.1 – Design Tables
  - Tables 1 – 5
  - Specify minimum required steel area
- Section 7.2 – Modified/Special Designs
  - Permitted for situations not covered by the design tables
  - Submit proof of adequacy of the design
  - Must be approved by the owner

ASTM C76

- Section 8.1.5 – Circ. Wire Spacing
  - Based on wall thickness
  - 4” Max for up to 4” wall thickness
  - Equal to wall thickness for 4” – 6” wall thickness
  - 6” absolute maximum
- **What Is A Proper Number Of Longitudinals?**
- Section 8.2 – Longitudinals
  - Not specified , must contain sufficient longitudinal bars or members, to maintain the reinforcement in shape and in position within the form

ASTM C76

- Section 8.1
- What Is A “Line” Of Reinforcement & What Is A “Layer” Of Reinforcement?
  - A “Line” may be made of a single Layer or multiple Layers
  - Two layers allowed for pipe wall less than 7”
  - Three layers allowed for pipe wall 7” or larger
  - Layers separated by maximum thickness of one longitudinal + 1/4”

ASTM C76

- Section 8.1.1 - Single Cage
  - Placed 35% - 50% of wall thickness from inside wall
  - Pipe with wall thickness <2 1/2”, Cover = 3/4”
- Section 8.1.2 - Double Cage
  - Circular Cages - Concrete cover = 1”
- Section 8.1.3 – Elliptical Cage
  - Elliptical Cages – Cover = 1” from wall in tension (3/4” for wall < 2 1/2”)
- Section 8.1.4
  - Location of reinforcement subject to permissible variations of Section 12.5

ASTM C76

- Section 12.5 - Permissible Variations
  - Position of reinforcement, +/- 10% of wall thickness, or +/- 1/2” whichever is greater
- **If your cage is outside this permissible variation, is the pipe automatically rejected?**
  - Variations exceeding those above shall be accepted if D-load passes
  - Must maintain minimum cover requirements (1/2” from any surface except: 1/4” from end of spigot, mating surfaces of nonrubber gasket joints or gasket groove)

ASTM C76

- Section 8.3 - Joint Reinforcement
- Non-rubber gasket joint
  - For pipe 36” & larger, either the bell or spigot shall contain circumferential reinforcement
- Rubber gasket joint
  - For pipe 12” & larger, the bell ends shall contain circumferential reinforcement

ASTM C76

- Section 8.1.8 - Splices
- Welding
  - Lap = min 2”, and a weld of sufficient length that pull test = at least 50% of min specified tensile strength of the steel
  - butt-welded splices permitted only with helically wound cages, Strength = 75% of min specified strength of the steel
- Lapping
  - Lap = 20/40 Bar Diameters (Deformed/Plain)
  - WWR lap must contain a longitudinal

ASTM C478

Sections 6.4.1 and 6.4.2 contain the same wording as for Sections 8.1.8 and 8.1.8.1 of ASTM C76

ASTM C76

- Spacers & Chairs
- How many spacers/chairs should you have & where should they be placed?
- Section 8.2
  - The exposure of the ends of longitudinals, stirrups, or spacers that have been used to position the cages during the placement of the concrete shall not be a cause for rejection.

Use enough to maintain the cage in place!

ASTM C1433/1577

- Section 7 – Design
  - Design Tables
  - Modified/Special designs are allowed
  - Circ. Spacing = 2”–4”, Long spacing = 8” max
- Section 7.3 – Placement of Reinforcement
  - Subject to permissible variations of Section 12
- Section 7.4 – Laps & Welds
  - All splices made by lapping
  - Beware the Restricted Welding Zones!

ASTM C1433/1577

- Section 7.4 – Laps
  - The overlap measured between the outermost longitudinal wires of each fabric sheet shall not be less than the spacing of the longitudinal wires plus 2 in. but not less than 10 in.

QUALITY SCHOOL

ASTM C1433/1577

Do you know the Restricted Welding Zones?

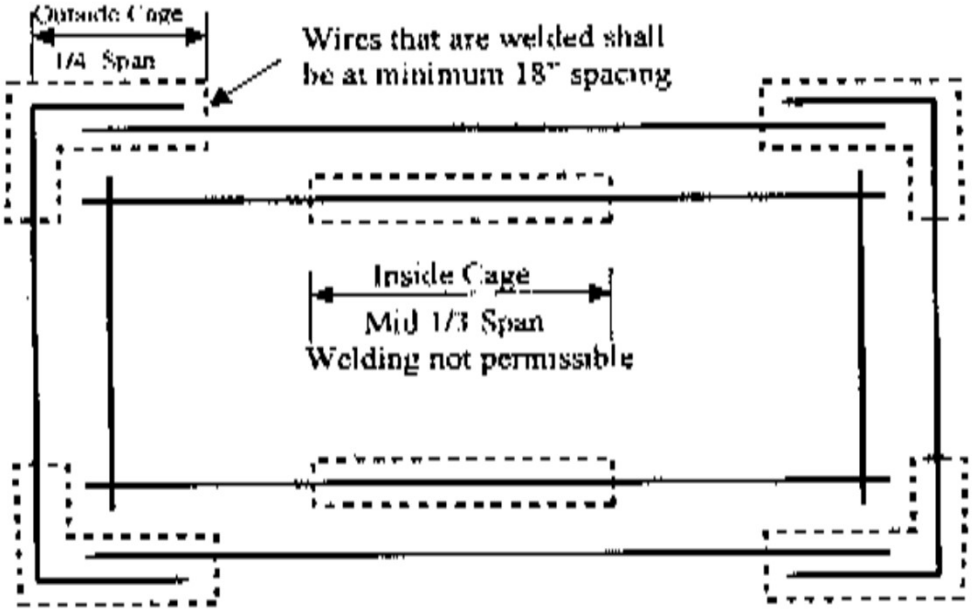


FIG. 9 Critical Zones of High Stress Where Welding is Restricted

What Makes a Good Cage?

- Right Steel Areas (Circumferential & Longitudinal)
- Correct Cage Dimensions
- Proper Lap &/or Good Welds
- Proper Spacers & Chairs
- Meet Specifications

Thank You

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ACPA

American Concrete Pipe Association