Section 5

Reinforced Concrete

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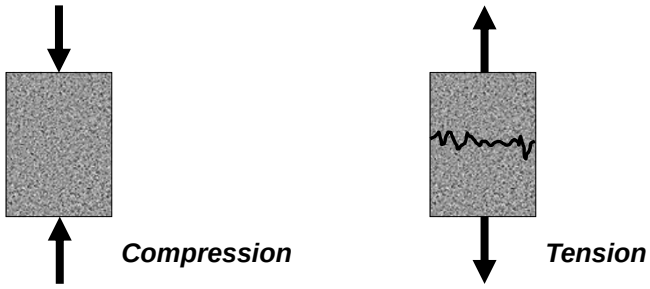
Concrete Cracks

Basics of Reinforced Concrete

- Concrete is strong in compression and weak in tension.



- Tensile capacity is approximately 10% of the compressive strength of concrete.

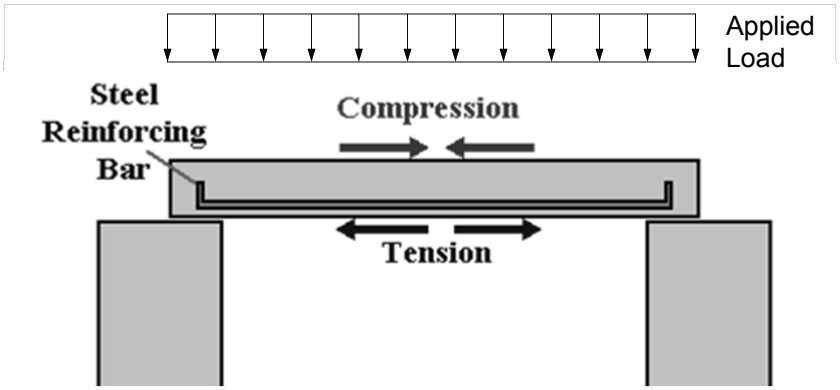
Beam Exercise

Basics of Reinforced Concrete Cont'd:

- Steel reinforcement is strong in tension.
- Reinforcement is added to carry tensile loads in concrete members.
- Temperature reinforcement is added to carry tensile loads due to thermal expansion of concrete members.

Why Use Rebar?

Simply supported beam example



View PCA Video

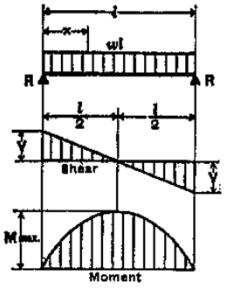
Fundamentals of Reinforcing
and Prestressed Concrete

(PCA VC114 ’88 Mod ‘07)

Structural Engineering Concepts

Shear & Moment Diagram
Uniformly Loaded Simple Beam

1. SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD



Total Equiv. Uniform Load . . . = wl

$R = V$ . . . . . = $\frac{wl}{2}$

V_x . . . . . = $w\left(\frac{l}{2} - x\right)$

M max. (at center) . . . . = $\frac{wl^2}{8}$

M_x . . . . . = $\frac{wx}{2}(l - x)$

Δmax. (at center) . . . . = $\frac{5\,wl^4}{384\,EI}$

Δ_x . . . . . = $\frac{wx}{24EI}(l^3 - 2lx^2 + x^3)$

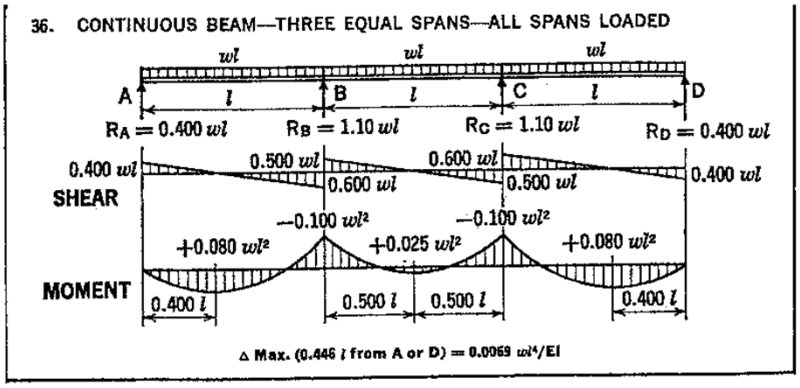
Maximum Shear Load at Bridge Ends and Piers

Tighter Stirrup Spacing
Near Abutments

Larger Stirrup Spacing
@ Midspan

Tighter Stirrup Spacing at Beam Ends

Shear & Moment Diagram
Uniformly Loaded Continuous 3 Span



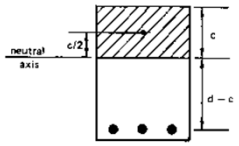
Uniformly Loaded Continuous Beam 3 Spans

Maximum negative moment in deck over piers.

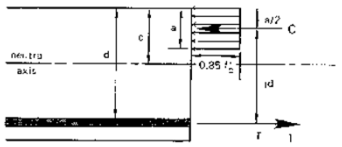
Additional longitudinal reinforcement added in top mat.

Beam Capacity

Strength of the Beam



Beam Cross-section

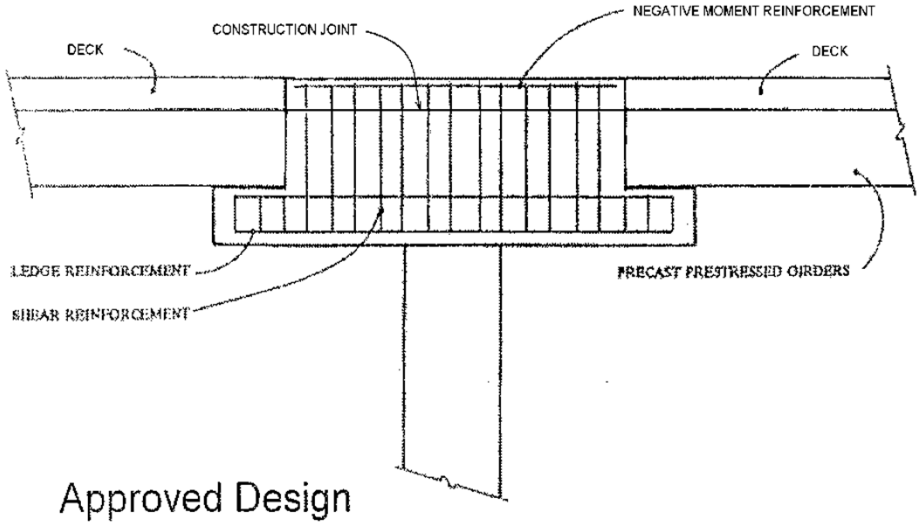


Beam Side View

$M = A_{st}f_y(d-1/2a) = 0.85f_c'ab(d-1/2a)$

Case Study
I-25: Walnut Street
Denver, CO

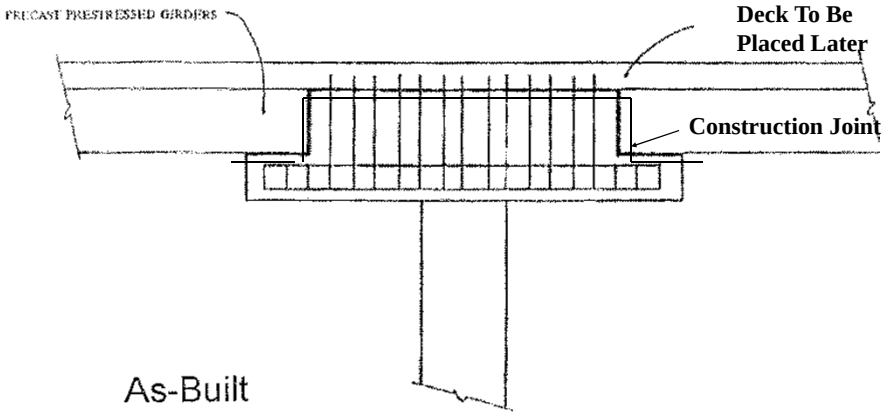
WALNUT STREET



Approved Design

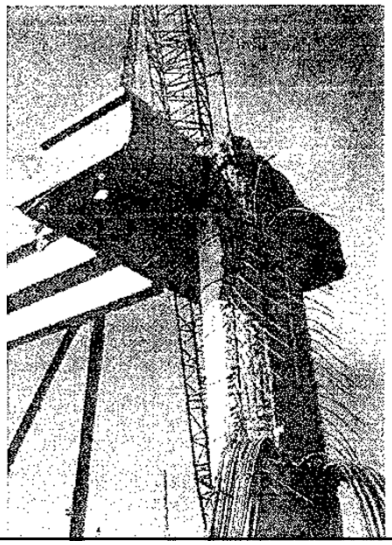
Thoughts?

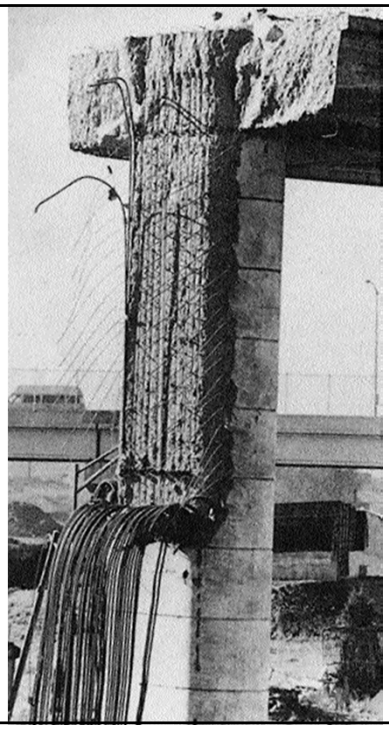
WALNUT STREET



As-Built

I-25: Walnut Street Pier Collapse





Pier Collapse

I-25: Walnut Street, Denver, CO

Oct. 4, 1985

Fatalities: 1

Injuries: 4

Reinforcement Inspection

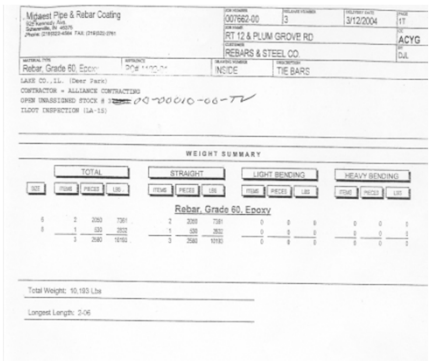
View CRSI Video

CRSI Field Insp Reinf Bars Mod 08

Type of Reinforcement

- Source
- Certifications
- Grade
- Epoxy coated or uncoated or stainless

Documentation



Midwest Pipe & Rebar Coating
525 Kennedy Ave.
Schererville, IN 46375
Phone: 219-322-4564 Fax 219-322-2761

007662-00 | 3 | 3/12/2004 | 1T
RT 12 & PLUM GROVE RD | ACYG
REBARS & STEEL CO. | DJL
Rebar, Grade 60, Epoxy | INSIDE | TIE BARS

LAKE CO., ILL. (Deer Park)
CONTRACTOR = ALLIANCE CONTRACTING
OPEN UNASSIGNED STOCK # 07-00010-06-TV
FLOOR INSPECTION (LA-15)

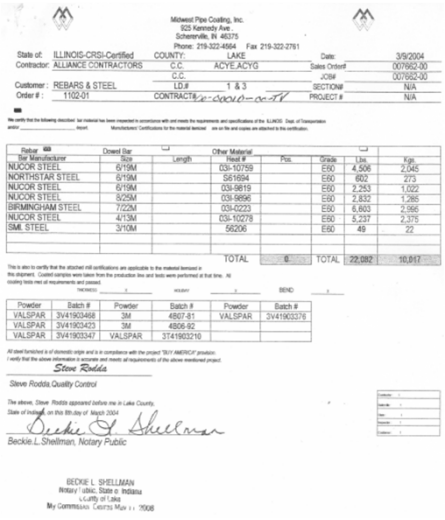
WEIGHT SUMMARY

	TOTAL			STRAIGHT			LIGHT BENDING			HEAVY BENDING		
SIZE	PCS	PIECE	LBS	PCS	PIECE	LBS	PCS	PIECE	LBS	PCS	PIECE	LBS
6	2	2093	7381	2	2093	7381	0	0	0	0	0	0
8	1	522	2922	1	522	2922	0	0	0	0	0	0
	3	2580	10193	3	2580	10193	0	0	0	0	0	0

Rebar, Grade 60, Epoxy

Total Weight: 10,193 Lbs
Longest Length: 2-06

Bills of material – what was delivered



Midwest Pipe Coating, Inc.
525 Kennedy Ave.
Schererville, IN 46375
Phone: 219-322-4564 Fax 219-322-2761

State of: ILLINOIS-CRSI-Certified | COUNTY: LAKE | Date: 3/9/2004
Contractor: ALLIANCE CONTRACTORS | C.C. ACYE,ACYG | Sales Order# 007662-00
C.C. | JOB# 007662-00
Customer: REBARS & STEEL | LD.# 1 & 3 | SECTION# N/A
Order # : 1102-01 | CONTRACT# 07-00010-06-TV | PROJECT # N/A

Rebar Bar Manufacturer	Dowel Bar Size	Length	Other Material Heat #	Pcs.	Grade	Lbs.	Kgs.
NUCOR STEEL	6/19M		03I-10759		E60	4,506	2,045
NORTHSTAR STEEL	6/19M		S61694		E60	602	273
NUCOR STEEL	6/19M		03I-9819		E60	2,253	1,022
NUCOR STEEL	8/25M		03I-9896		E60	2,832	1,285
BIRMINGHAM STEEL	7/22M		03I-0223		E60	6,603	2,996
NUCOR STEEL	4/13M		03I-10278		E60	5,237	2,375
SMI. STEEL	3/10M		56206		E60	49	22
			TOTAL	0	TOTAL	22,082	10,017

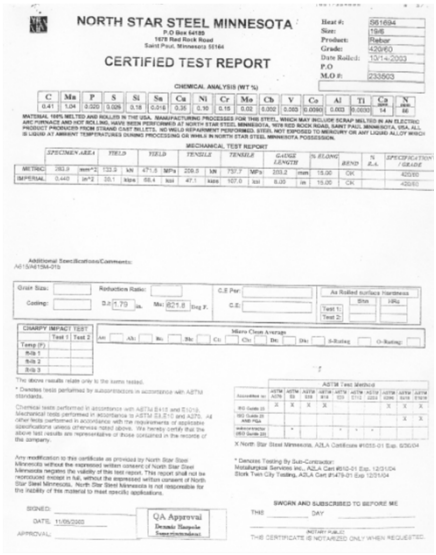
Powder	Batch #	Powder	Batch #	Powder	Batch #
VALSPAR	3V41903468	3M	4807-81	VALSPAR	3V41903376
VALSPAR	3V41903423	3M	4806-92		
VALSPAR	3V41903347	VALSPAR	3T41903210		

Steve Rodda, Quality Control

Beckie L. Shellman, Notary Public

BECKIE L. SHELLMAN
Notary Public, State of Indiana
Lake County
My Commission Expires May 11, 2008

Certifications



NORTH STAR STEEL MINNESOTA
P.O Box 64185
1678 Red Rock Road
Saint Paul, Minnesota 55164

CERTIFIED TEST REPORT

Heat #: S61694
Size: 19#
Product: Rebar
Grade: 420/60
Date Rolled: 10/14-2003
P.O
M.O #: 233503

CHEMICAL ANALYSIS (WT %)

C	Mn	P	S	Si	Sn	Cu	Ni	Cr	Mo	Cb	V	Co	Al	Ti	Ca	N
0.41	1.04	0.020	0.029	0.18	0.014	0.30	0.10	0.15	0.02	0.002	0.005	0.0050	0.003	0.0030	14	80

MATERIAL 100% MELTED AND ROLLED IN THE USA. MANUFACTURING PROCESSES FOR THIS STEEL, WHICH MAY INCLUDE SCRAP MELTED IN AN ELECTRIC ARC FURNACE AND HOT ROLLING, HAVE BEEN PERFORMED AT NORTH STAR STEEL MINNESOTA, 1678 RED ROCK ROAD, SAINT PAUL, MINNESOTA, USA. ALL PRODUCT PRODUCED FROM STRAND CAST BILLETS. NO WELD REPAIRMENT PERFORMED. STEEL NOT EXPOSED TO MERCURY OR ANY LIQUID ALLOY WHICH IS LIQUID AT AMBIENT TEMPERATURES DURING PROCESSING OR WHILE IN NORTH STAR STEEL MINNESOTA POSSESSION.

MECHANICAL TEST REPORT

	SPECIMEN AREA		YIELD		TENSILE		GAUGE LENGTH		% ELONG	BEND	% R.A.	SPECIFICATION / GRADE
METRIC	283.9	mm^2	122.3	kN	471.5	MPa	206.0	kN	737.7	MPa	203.2	mm	15.00	OK		420/60
IMPERIAL	0.440	in^2	20.1	kips	68.4	ksi	47.1	kips	107.0	ksi	8.00	in	15.00	OK		420/60

Additional Specifications/Comments:
A615/A615M-01b

Grain Size:
Reduction Ratio:
C.E Per:
Coiling:
D.A 1.79 in. Mu: 821.6 Deg F.
C.E:
As Rolled surface Hardness: Brin / Rkw
Test 1:
Test 2:

CHARPY IMPACT TEST

	Test 1	Test 2
Temp (F)		
Avg 1		
Avg 2		
Avg 3		

Macro Grain Average
Mn: Si: Cr: Cu: Mo: Ni: S-Rating: O-Rating:

The above results relate only to the items tested.

* Denotes tests performed by subcontractors in accordance with ASTM standards.

Chemical tests performed in accordance with ASTM E415 and E1019. Mechanical tests performed in accordance to ASTM E8/E8 and A370. All other tests performed in accordance with the requirements of applicable specifications unless otherwise noted above. We hereby certify that the above test results are representative of those contained in the records of the company.

Any modification to this certificate as provided by North Star Steel Minnesota without the expressed written consent of North Star Steel Minnesota negates the validity of this test report. This report shall not be reproduced except in full, without the expressed written consent of North Star Steel Minnesota. North Star Steel Minnesota is not responsible for the liability of this material to meet specific applications.

ASTM Test Method

Specification no.	ASTM A370	ASTM A615	ASTM A706	ASTM A370	ASTM A615	ASTM A706	ASTM A370	ASTM A615	ASTM A706
ISO Grade 15	X	X	X				X	X	X
ISO Grade 20 AND 15A									
Intermediate (ISO Grade 20)									

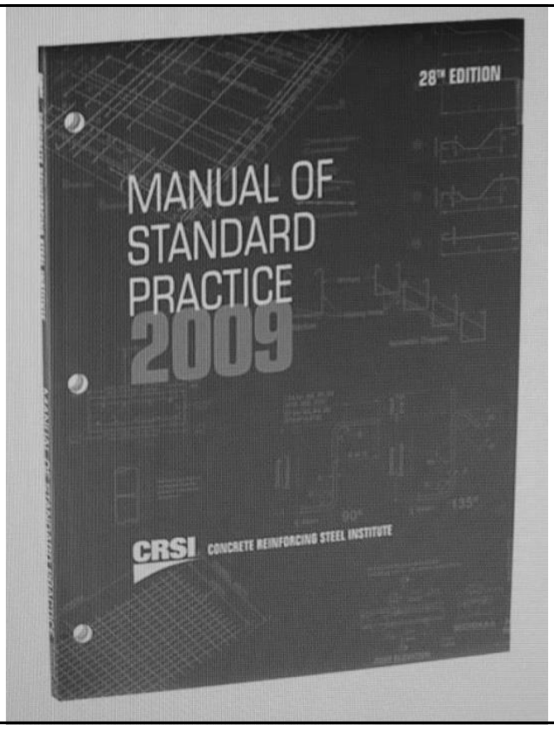
X North Star Steel Minnesota, AZLA Certificate #1033-01 Exp. 6/30/04

* Denotes Testing By Sub-Contractor:
Metallurgical Services Inc., AZLA Cert #510-01 Exp. 12/31/04
Stork Twin City Testing, AZLA Cert #479-01 Exp 12/31/04

SIGNED:
DATE: 11/05/2003
APPROVAL:
QA Approval
Tamatic Reigstin

SWORN AND SUBSCRIBED TO BEFORE ME
THIS DAY
NOTARY PUBLIC
THIS CERTIFICATE IS NOT VALID ONLY WHEN REQUESTED.

Rebar (steel) mill certificate



ASTM STANDARD INCH-POUND REINFORCING BARS

BAR SIZE DESIGNATION	NOMINAL DIMENSIONS		
	AREA (in.²)	WEIGHT (lb/ft)	DIAMETER (in.)
#3	0.11	0.376	0.375
#4	0.20	0.668	0.500
#5	0.31	1.043	0.625
#6	0.44	1.502	0.750
#7	0.60	2.044	0.875
#8	0.79	2.670	1.000
#9	1.00	3.400	1.128
#10	1.27	4.303	1.270
#11	1.56	5.313	1.410
#14	2.25	7.65	1.693
#18	4.00	13.60	2.257

The current A615 specification covers bar sizes #14 and #18 in Grade 60, and bar sizes #11, #14 and #18 in Grade 75. The current A706 specification also covers bar sizes #14 and #18. Bar sizes #9 through #18 are not included in the A996 specification.

English Rebar Numbers

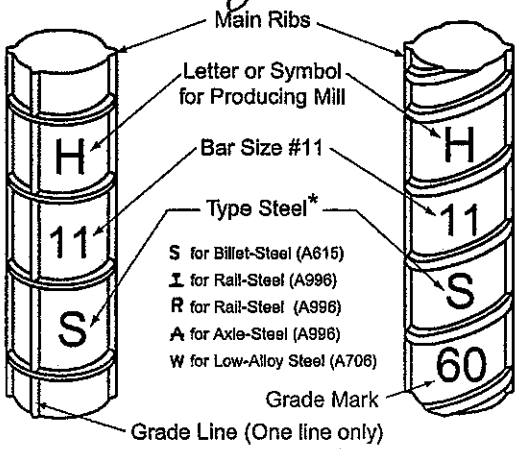
- #3 - #8; Diameter in 1/8″ units
  #8/8 = 1″ dia.
- #9 - #18; Based on area of square bars formerly used with sides of 1″, 1-1/8″, 1-1/4″, 1-1/2″ & 2″ and then rounded to closest 1/8″ unit diameter.

Metric to English Bar Conversion

- (Bar # - 1) divided by 3 then round to nearest english bar #
- #25 metric = (25-1)/3 = #8 english

MATERIAL SPECIFICATIONS FOR REINFORCING BARS

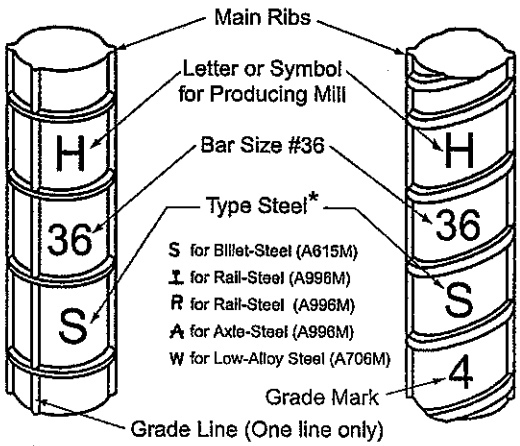
English



*Bars marked with an S and W meet both A615 and A706

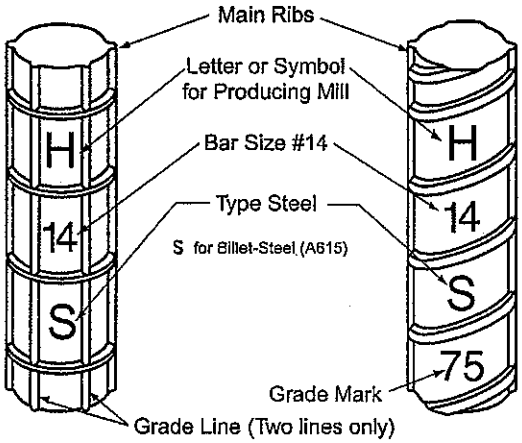
GRADE 60

Metric

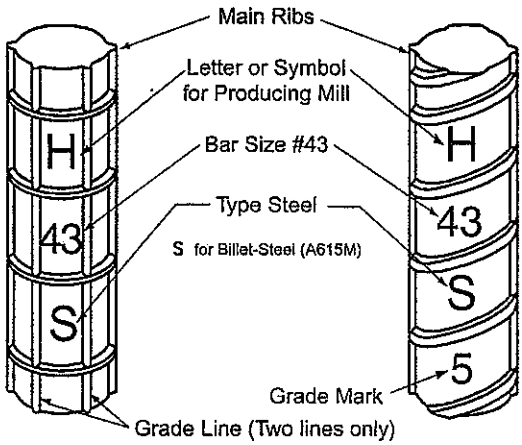


*Bars marked with an S and W meet both A615 and A706

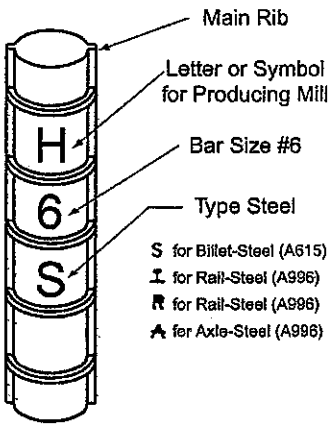
GRADE 420



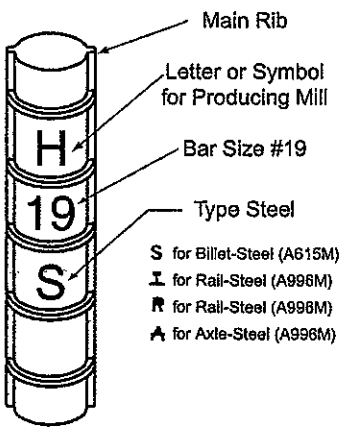
GRADE 75



GRADE 520



GRADES 40 AND 50



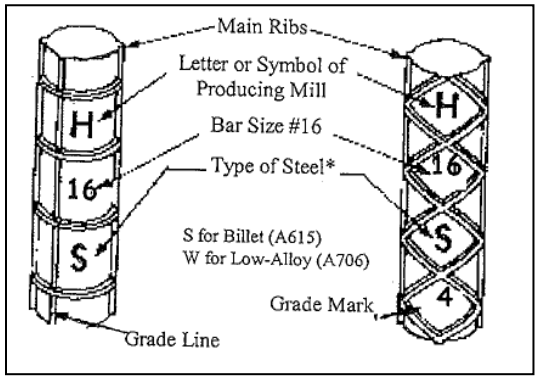
GRADES 300 AND 350

QPL Appendix A

http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/QPL/Docs/QPL.pdf

Appendix A—Approved Reinforcing Steel Producers

The ASTM specifications for billet-steel and low-alloy reinforcing bars (A615 and A706, respectively) require identification marks to be rolled into the surface of one side of the bar to denote the producer's mill designation, bar size, type of steel and minimum yield designation. Grade 420 bars show these marks in the following order:



1st ---Producing Mill (usually a letter)

2nd --- Bar Size Number (# 4 through # 18)

3rd --- Type of Steel: **S** Billet (A 615)
W for Low Alloy (A 706)

4th ---Minimum Yield Designation

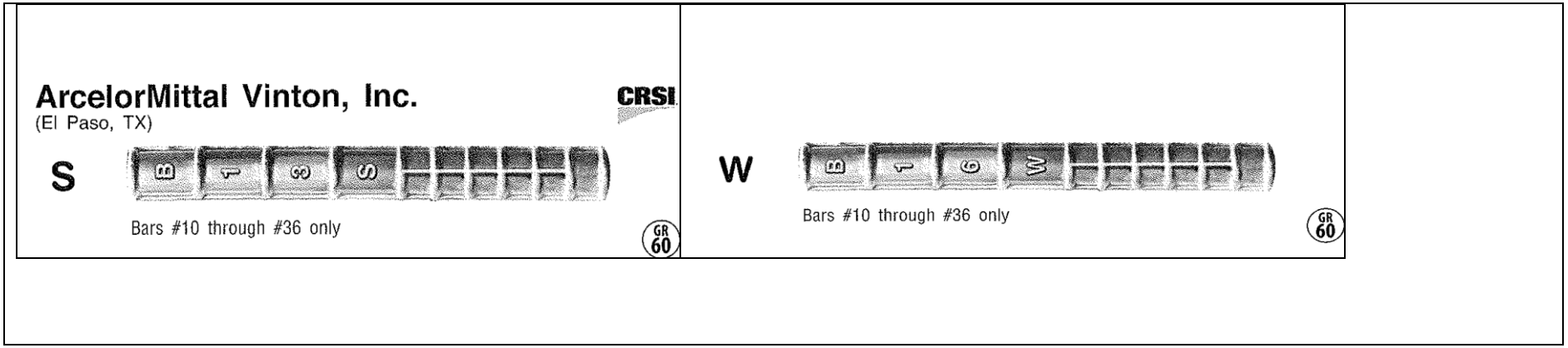
The minimum yield designation for Grade 420 bars is either one (1) single, longitudinal line (grade line) or the number 4 (grade mark).

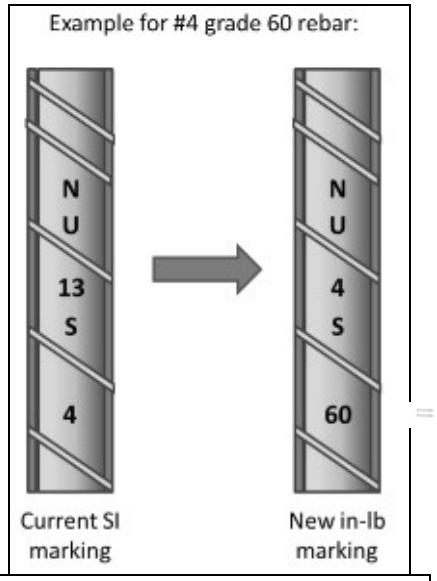
A grade line is smaller and is located between the two main ribs, which are on opposite sides of all bars made in the United States. A grade line must be continued through at least 5 deformation spaces, and it may be placed on the side of the bar opposite the bar marks. A grade mark is the fourth mark on the bar.

VARIATIONS: Bar identification marks may also be oriented to read horizontally (90° to those illustrated). Grade numbers may be placed within consecutive deformation spaces to read vertically or horizontally.

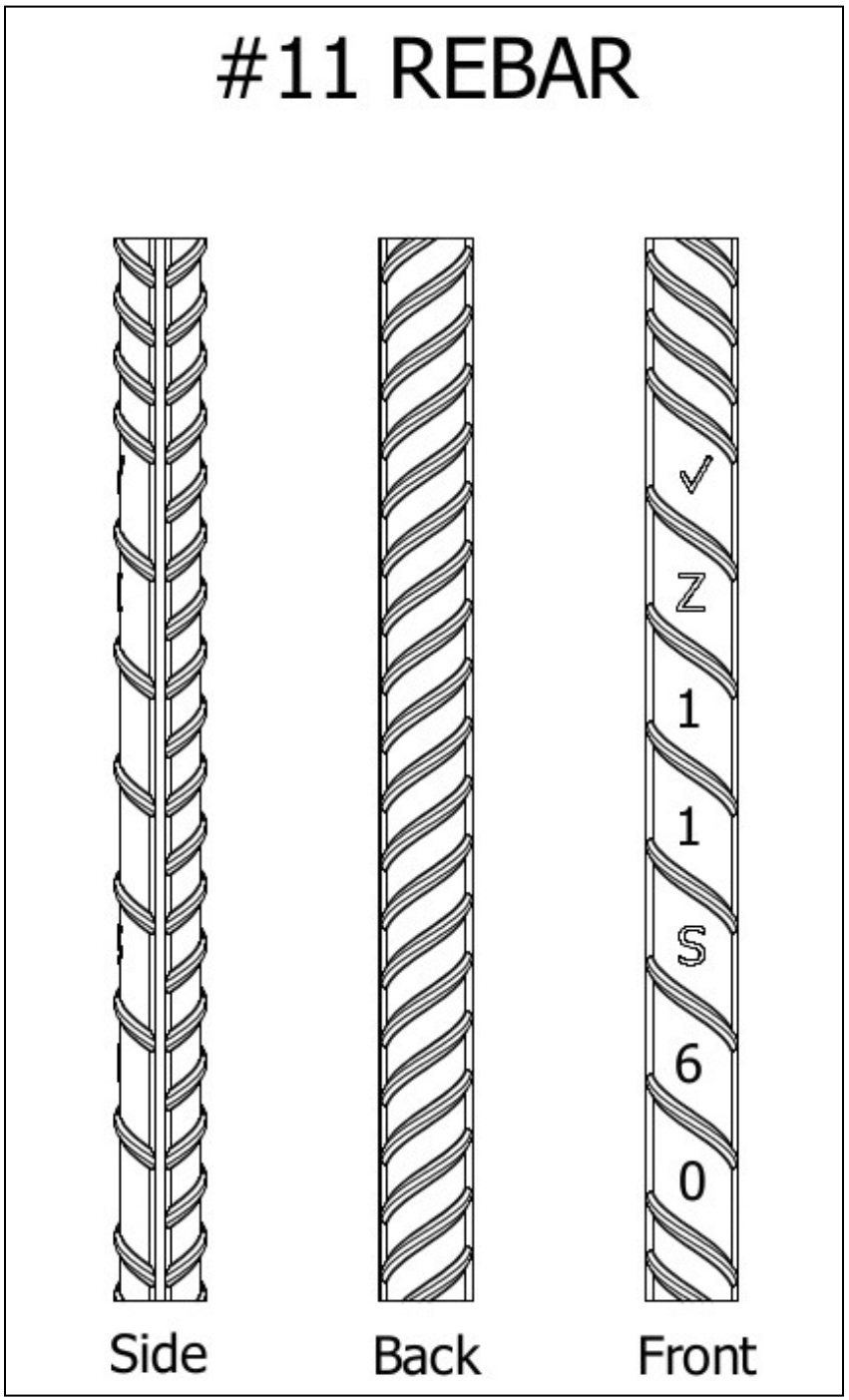
The Identification marks for the Approved Producers are shown in the following figures. Rebar grades shown on these pages are for reference only. Check the specs for the appropriate requirements.

ArcelorMittal Vinton, Inc. El Paso Texas ODOT # 1841

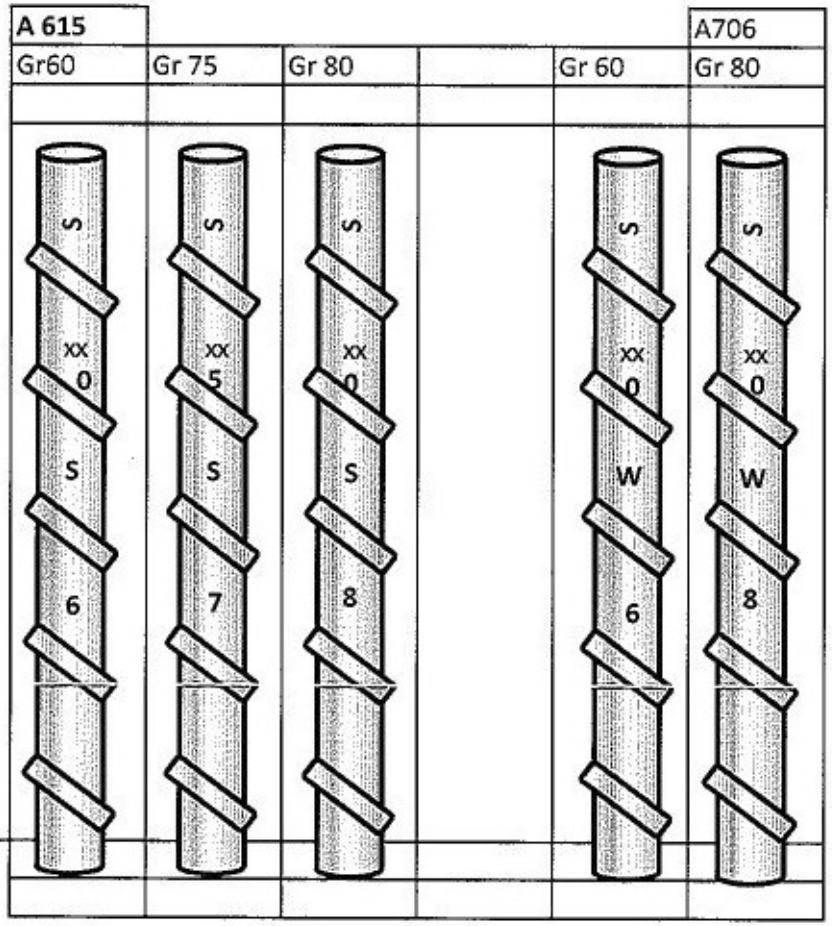




Nucor Steel Utah ODOT # 1112

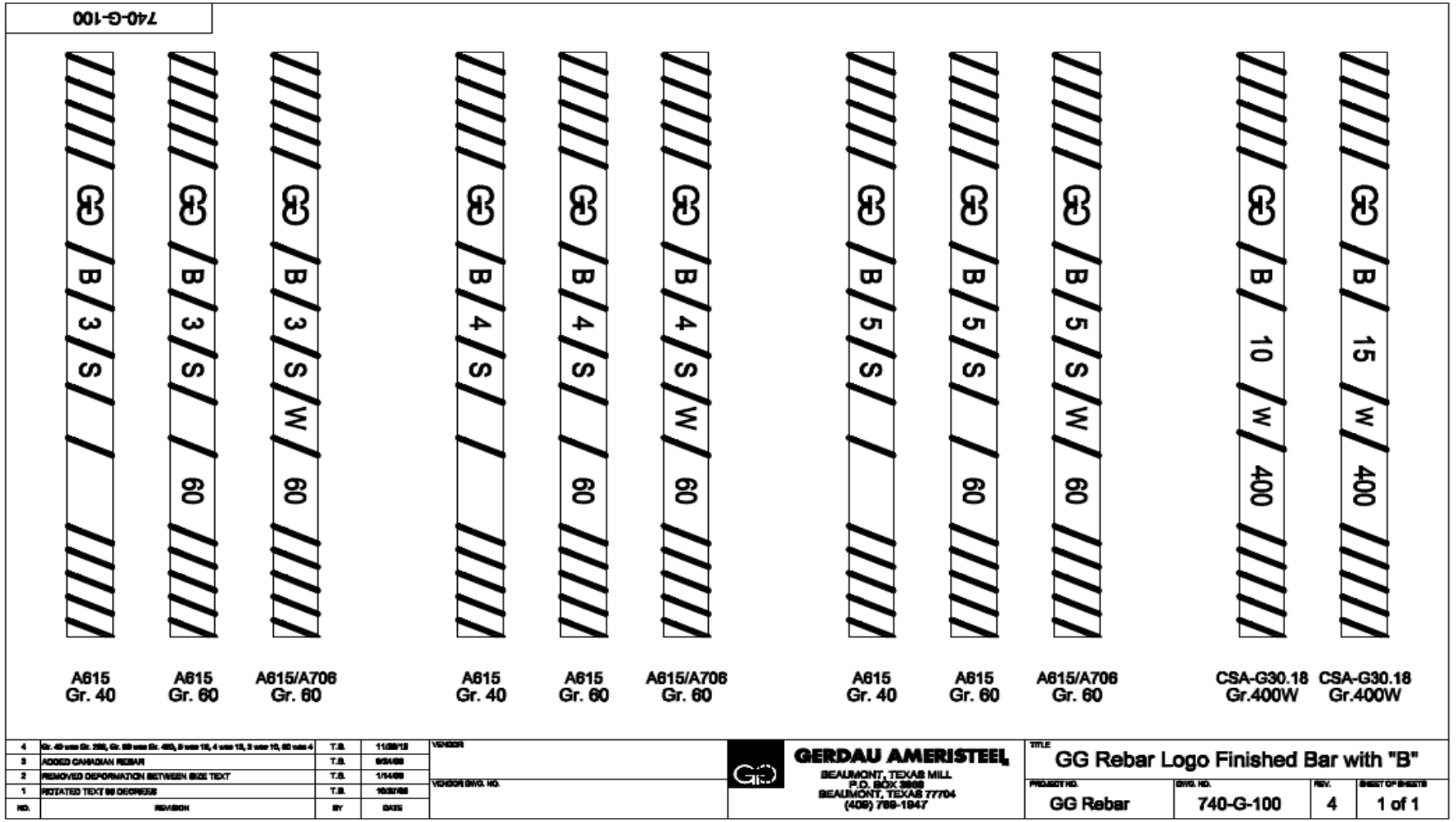


CMC Steel Mesa Arizona ODOT #4118

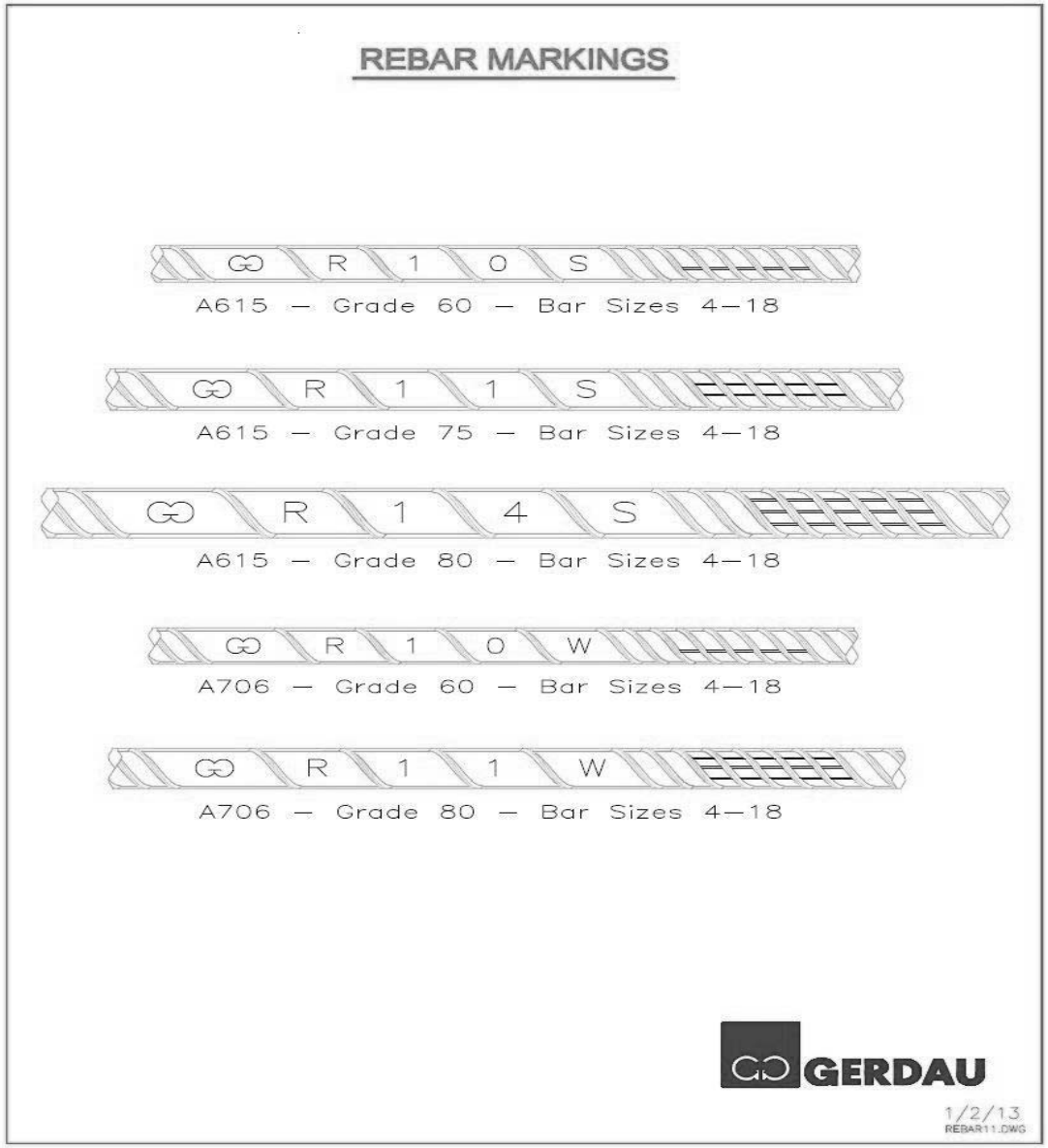


Bar sizes 4, 5, 6, 7, 8, 9, 10, 11, 14, 18.

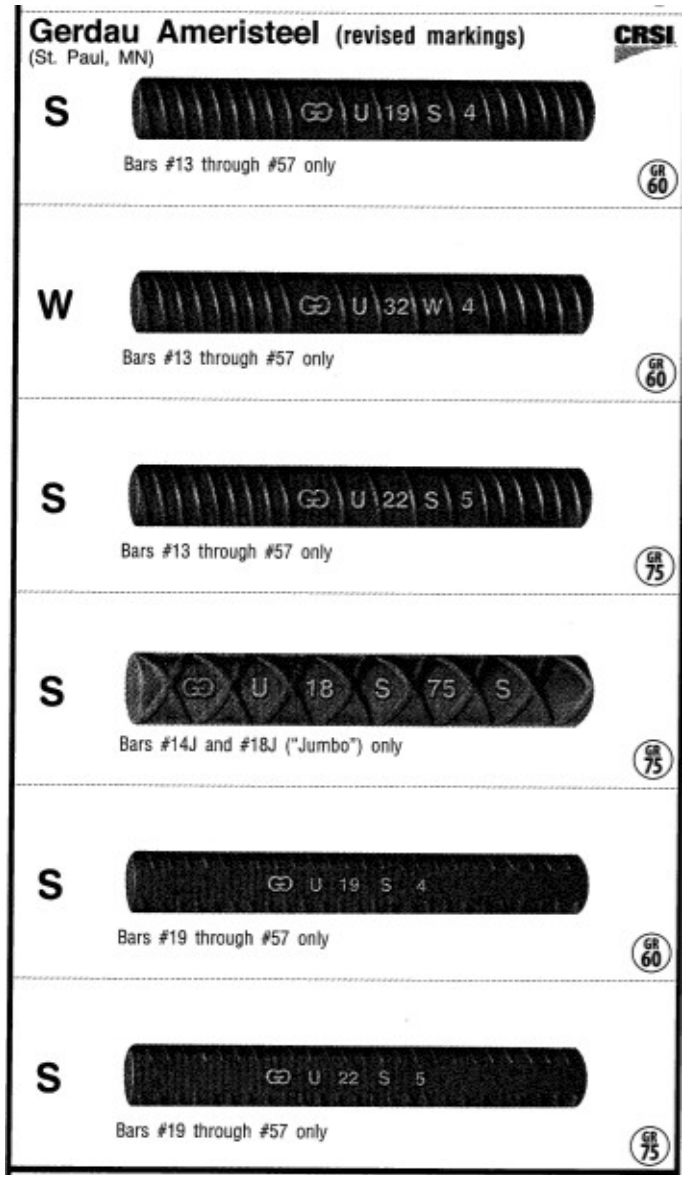
Nucor Steel Seattle Washington ODOT # 2935



Gerdau Steel Beaumont Texas ODOT #4838



Gerdau at Rancho Cucamonga California ODOT # 1842



Gerdau St. Paul Minnesota ODOT # 1623

Cascade Steel Mc-Minnville Oregon
ODOT # 1111

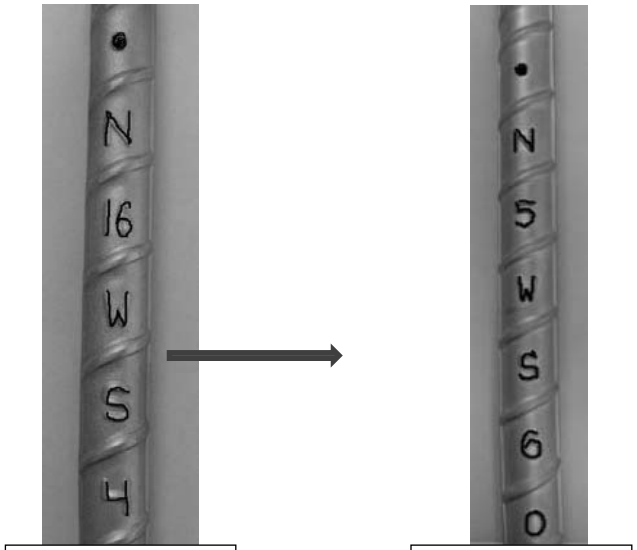
Cascade Steel Rolling Mills, Inc.
(McMinnville, OR)

CRSI Concrete Reinforcing Steel Institute MEMBER

S GR 60		Bars #3 through #6 only	
W GR 60		Bars #3 through #6 only	
W GR 60		Bars #14 and #18 only	
SW GR 60		Bars #3 through #11 only (#3 through #6 coiled)	
SW GR 60		Bars #14 and #18 only	
S GR 75		Bars #3 through #11 only (#3 through #6 coiled)	
S GR 75		Bars #14 and #18 only	
S GR 80		Bars #3 through #11 only	
S GR 80		Bars #14 and #18 only	
W GR 80		Bars #3 through #11 only	
W GR 80		Bars #14 and #18 only	
SW GR 80		Bars #3 through #6 coiled	

A706/A615 GRADE 60 REBARS MARKINGS
Rebar sizes: #3 thru #6

NUCOR STEEL – KINGMAN, AZ
ODOT #4356



Current SI Marking

New IN-LBS

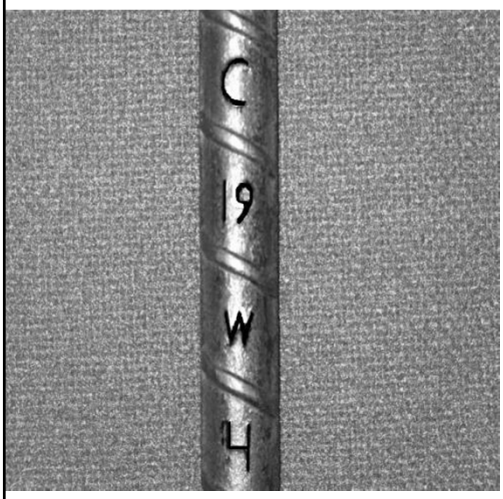
Rebar Exercise

Mill:
Size:
Dia:
Type:
Grade:

Rebar Exercise Key

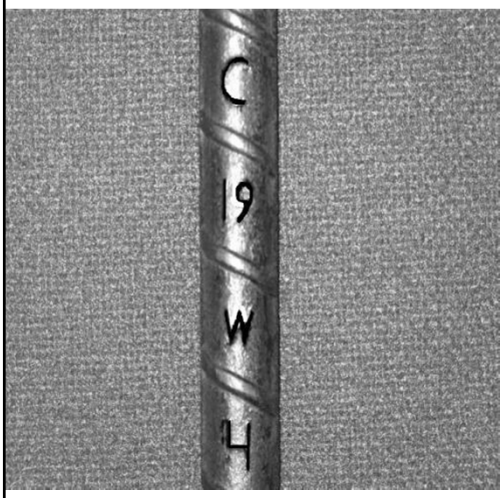
Mill: Cascade
Size: #16
Dia: 0.625″
Type: Billet (A615M)
Grade: 420

Rebar Exercise



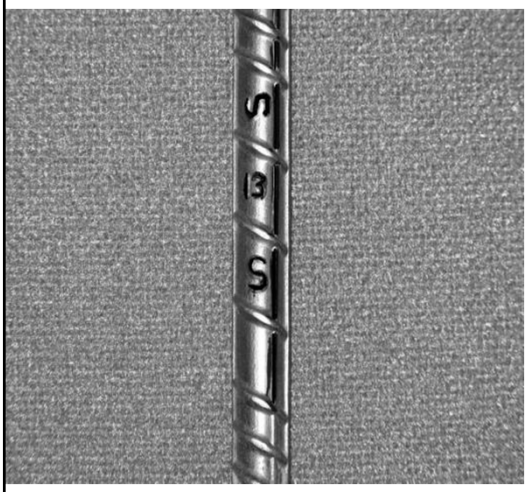
Mill:
Size:
Dia:
Type:
Grade:

Rebar Exercise Key



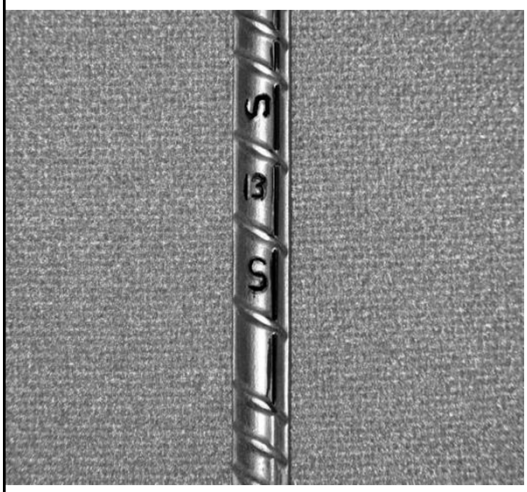
Mill: Cascade
Size: #19
Dia: 0.75″
Type: A706M
Grade: 420

Rebar Exercise



Mill:
Size:
Dia:
Type:
Grade:

Rebar Exercise Key

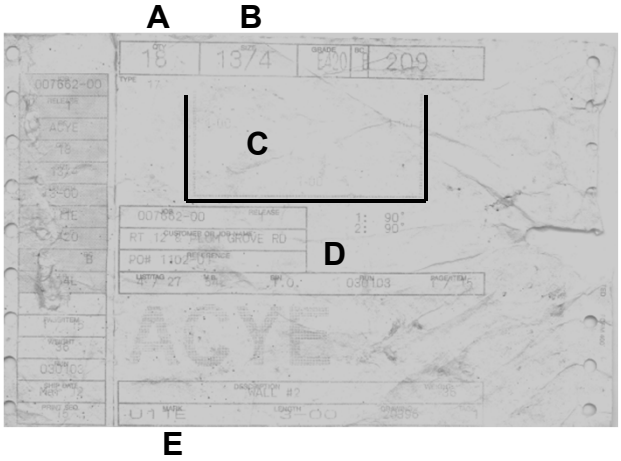


Mill: Nucor
Size: #13
Dia: 0.50″
Type: Billet (A615M)
Grade: 420

Size & Shape

- Bar size
- Bar length
- Bar shape (correct radius)
- Agrees with shop drawings

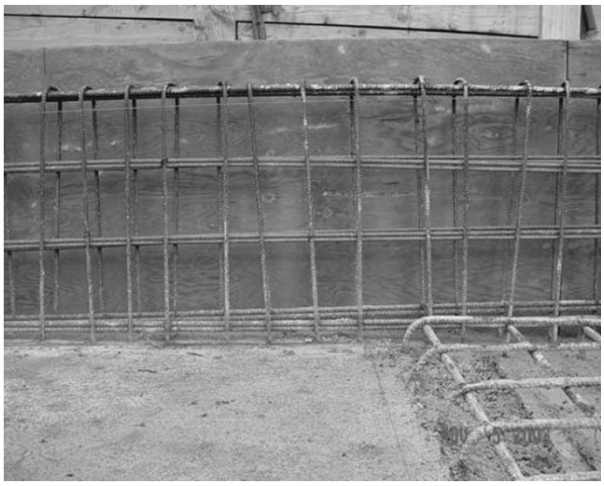
REBAR MATERIAL TAG



A. Quantity
B. Size
C. Bend diagram
D. Project
E. Bar ID or mark

→ Verify

Doubled Up Horizontal Bars in Abutment?



Hooked Bar in Middle of Deck by Itself?

Rebar Condition

Condition

- Look for any loose scale or rust, grease, oil, paint, or other foreign material that could harm the bond with the concrete.
- Properly stored off the ground to avoid water and mud which can cause corrosion.
- Do not use cracked or split bars (look at bends).
- Look for epoxy damage.

Field Bent Bars?

Epoxy Damage

Rebar Jobsite Storage

Total exposure time of epoxy-coated bar in storage or in place is not to exceed 2 months without covering. (530.40)

Epoxy breaks down under prolonged UV exposure – it gets **chalky**

Faded Epoxy & Bare Ties?

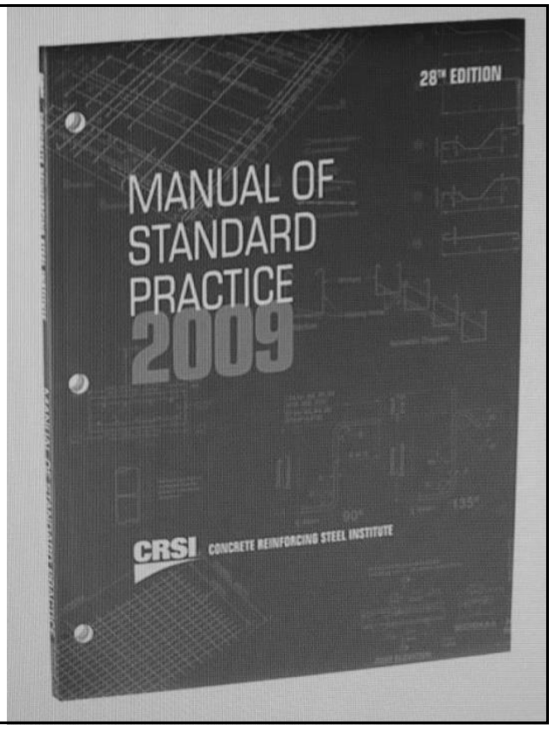
View WCI Video

Jobsite Handling Epoxy Coated Rebar

Layout

- Number
- Spacing
- Alignment

Placement Tolerances according to "Manual of Standard Practice" 530.41



Effective Depth "d"

Distance from the compression face of the beam to the centroid of the reinforcement

CHAPTER 8

RECOMMENDED INDUSTRY PRACTICE FOR PLACING REINFORCING BARS*

8.1 Introduction

This Chapter presents recommendations for placing reinforcing bars and is based upon industry practices that are in accordance with the ACI Building Code.

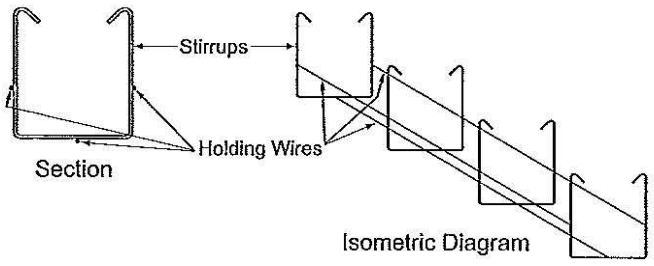
Reinforcing bars should be accurately placed in the positions shown on the placing drawings, adequately tied and supported before concrete is placed, and secured against displacement within the tolerances recommended in Section 8.8.

8.2 Welding of Reinforcing Bars

Welding of crossing bars (tack welding) should not be permitted for assembly of reinforcement unless authorized by the Architect/Engineer.

Electric resistance welds performed by computer-controlled, electronically operated welding machines in fabricating shops should be wholly differentiated from field tack welding. These electric resistance welds use a fusion process that does not introduce foreign matter to the bars or change their composition. This welding process is the same that is used for structural welded wire reinforcement (ASTM A185/A185M or A497/A497M) which is widely accepted in beams, slabs and columns. Reinforcing bar assemblies built with high-tech resistance welding machines in fabricating shops should be acceptable so long as the reinforcing bars conform to ASTM A706, holding wires conform to ASTM A82/A82M or A496/A496M, machines are operated under a continuous controlled process and test results for shop-welded specimens can be made available to the Architect/Engineer.

The holding wires serve no structural purpose but are there only to hold the reinforcement in place and, therefore, need not be subject to the same tensile, yield and elongation requirements as for the reinforcing bars.



8.3 Surface Condition of Reinforcing Bars

At the time of concrete placement, all reinforcing bars should be free of mud, oil, or other deleterious materials. Reinforcing bars with rust, mill scale, or a combination of both should be considered as satisfactory, provided the minimum dimensions, weight, and height of deformations of a hand-wire-brushed test specimen are not less than the applicable ASTM specification requirements.

8.4 Field Bending of Reinforcing Bars

Reinforcing bars should not be field bent or straightened in a manner that will reduce their strength or ductility. Bars with kinks or improper bends should not be used. No reinforcing bars partially embedded in hardened concrete should be field bent, except for:

1. Realignment of #3 through #6 [#10 through #19] bars up to about a 45° bend.
2. Realignment of #7 through #18 [#22 through #57] bars up to about 30° bend.
3. Those reinforcing bars as shown on the project drawings or permitted by the Architect/Engineer.

8.5 Spacing of Reinforcing Bars

The clear distance between parallel reinforcing bars in a layer should not be less than the nominal diameter of the bars, nor 1 inch [25 mm]. Clear distance should also not be less than one and one-third times the nominal maximum size of the coarse aggregate, except if in the judgment of the Architect/Engineer, workability and methods of consolidation are such that concrete can be placed without honeycomb or voids.

Where parallel reinforcement is placed in two or more layers, the bars in the upper layers should be placed directly above those in the bottom layer with the clear distance between layers not less than 1 inch [25 mm].

Groups of parallel reinforcing bars bundled in contact, assumed to act as a unit, not more than four in any one bundle may be used only when stirrups or ties enclose the bundle. Reinforcing bars larger than #11 [#36] should not be bundled in beams or girders. Individual bars in a bundle cut off within the span of flexural members should terminate at different points with at least 40 bar diameters of stagger. Where spacing limitations and minimum concrete cover are based on bar size, a unit of bundled bars should be treated as a single bar of a diameter derived from the equivalent total area.

In walls and slabs other than concrete joist construction, the principal reinforcement should not be spaced farther apart than three times the wall or slab thickness, nor more than 18 inches [450 mm].

In spirally reinforced and tied columns, the clear distance between longitudinal reinforcing bars should not be less than one and one-half times the nominal bar diameter, nor 1-1/2 inches [40 mm].

The clear distance limitation between bars should also apply to the clear distance between a contact lap splice and adjacent splices or bars.

*For further recommendations on bar placement, see *Placing Reinforcing Bars* available from the Concrete Reinforcing Steel Institute.

CHAPTER 8

RECOMMENDED INDUSTRY PRACTICE FOR PLACING REINFORCING BARS

8.6 Splices in Reinforcing Bars**

8.6.1 General

Splicing of reinforcing bars should be either lap splices, mechanical splices or welded splices.

Splices of reinforcing bars should be made only as required or permitted on the project drawings or in the project specifications, or as authorized by the Architect/Engineer.

8.6.2 Lap Splices

Lap splices of #14 and #18 [#43 and #57] bars should not be used, except in compression only to #11 [#36] and smaller bars.

Lap splices of bundled bars should be based on the lap splice length recommended for individual bars of the same size as the bars spliced, and such individual splices within the bundle should not overlap each other. The length of lap should be increased 20 percent for a 3-bar bundle and 33 percent for a 4-bar bundle.

Bar laps placed in contact should be securely wired together in such a manner as to maintain the alignment of the bars and to provide minimum clearances.

Bars spliced by noncontact lap splices in flexural members should not be spaced transversely farther apart than one-fifth the required length of lap nor 6 inches [150 mm].

8.6.3 Mechanical Splices

Mechanical splices should be installed in accordance with the Manufacturers' recommendations.

8.6.4 Welded Splices

All welding should conform to the current edition of "Structural Welding Code—Reinforcing Steel" (AWS D1.4/D1.4M).

8.7 Embedment and Extensions

Bottom reinforcing bars in beams should extend at least 6 inches [150 mm] into the support. Bottom bars in slabs or joists should extend into the support to the limits of the specified concrete cover or 6 inches [150 mm], whichever is less.

Generally, in one-way continuous construction, unless otherwise called for on the project drawings or in the project specifications, the top reinforcing bars should extend into adjacent spans to 0.30 of the greater clear span length beyond the far face of the support. Generally at discontinuous ends, top bars should extend into the span at least 0.25 of the clear span length beyond the face of the support and extend into the support to the specified concrete cover at the outer faces of the members into which they frame.

**See *Reinforcing Bars: Anchorages and Splices* by the Concrete Reinforcing Steel Institute.

For structural integrity, a prescribed portion of the bottom and top reinforcement must be made continuous with the reinforcement in the adjacent spans and terminate with a standard hook or headed bar at the exterior supports. See Section 4.14 in Chapter 4.

8.8 Tolerances in Placement

Unless otherwise specified, reinforcing bars should be placed within the following tolerances as per ACI 117:

1. Tolerance for depth, d, and specified concrete cover in flexural members, walls and columns should be as follows:

Effective depth	Tolerance on d	Tolerance on specified concrete cover
$d \leq 8$ in. [200 mm]	± 3/8 in. [10 mm]	– 3/8 in. [10 mm]
$d > 8$ in. [200 mm]	± 1/2 in. [12 mm]	– 1/2 in. [12 mm]

Note: d is the specified effective depth.

   Except that the tolerance for the clear distance to formed soffits should be –1/4 inch [6 mm], and the tolerance for concrete cover should not exceed minus one-third of the specified cover required on the project drawings or in the project specifications.
2. Tolerance for the longitudinal location of bends and ends of bars should be ±2 inches [50 mm] except at discontinuous ends of members where the tolerance should be ±1 inch [25 mm].
3. As long as the total number of bars specified is maintained, a reasonable tolerance in spacing individual bars is ±3 inches [75 mm], except where openings, inserts and embedded items might require some additional shifting of bars.
4. Tolerance for length of laps in lap splices should be –1 inch [25 mm].
5. Tolerance for embedded length should be –1 inch [25 mm] for #3 through #11 [#10 through #36] bars, and –2 inches [50 mm] for #14 and #18 [#43 and #57] bars.

8.9 Bar Supports

The use of bar supports should follow the industry practices presented in Chapter 3 of this *Manual*.

Placing reinforcement on layers of fresh concrete as the work progresses and adjusting the bars during the placing of concrete should not be permitted.

The required positioning of supports in post-tensioned construction to provide the proper profile of the tendons should be in accordance with the placing drawings provided by the post-tensioning Contractor and approved by the Architect/Engineer. The sequence of placing reinforcing bars in conjunction with tendons and/or ducts should be considered by the Architect/Engineer during the design phase.

CHAPTER 8

RECOMMENDED INDUSTRY PRACTICE FOR PLACING REINFORCING BARS

8.10 Concrete Protection for Reinforcing Bars

The following specified concrete cover, as per ACI 318, should be provided for reinforcing bars. For bundled bars, the specified cover should be equal to the equivalent diameter of the bundle but need not be greater than 2 inches [50 mm]; except for concrete cast against and permanently exposed to earth, the specified cover should be 3 inches [75 mm].

8.10.1 Cast-In-Place Concrete (nonprestressed)

	Concrete Cover in.	[mm]
Concrete cast against and permanently exposed to earth	3	[75]
Concrete exposed to earth or weather:		
#6 through #18 [#19 through #57]	2	[50]
#5 [#16] and smaller	1½	[40]
Concrete not exposed to weather or in contact with ground:		
Slabs, walls, joists:		
#14 and #18 [#43 and #57]	1½	[40]
#11 [#36] and smaller	¾	[20]
Beams, columns		
Primary reinforcement, ties, stirrups or spirals	1½	[40]
Shells, folded plate members:		
#6 [#19] and larger	¾	[20]
#5 [#16] and smaller	½	[15]

8.10.2 Precast Concrete (manufactured under plant control conditions)

	Concrete Cover in.	[mm]
Concrete exposed to earth or weather:		
Wall panels:		
#14 and #18 [#43 and #57]	1½	[40]
#11 [#36] and smaller	¾	[20]
Other members:		
#14 and #18 [#43 and #57]	2	[50]
#6 through #11 [#19 through #36]	1½	[40]
#5 [#16] and smaller	1¼	[30]
Concrete not exposed to weather or in contact with ground:		
Slabs, walls, joists:		
#14 and #18 [#43 and #57]	1¼	[30]
#11 [#36] and smaller	⅝	[15]
Beams, columns:		
Primary reinforcement	d_b*	
Ties, stirrups or spirals	⅜	[10]
Shells, folded plate members:		
#6 [#19] and larger	⅝	[15]
#5 [#16] and smaller	⅜	[10]

* But not less than 5/8 inches [15 mm] and need not exceed 1-1/2 inches [40 mm].

RECOMMENDED INDUSTRY PRACTICE FOR PLACING REINFORCING BARS

8.10.3 Post-Tensioned Concrete

	Concrete Cover in.	[mm]
Concrete cast against and permanently exposed to earth	3	[75]
Concrete exposed to earth or weather:		
Wall panels, slabs, joists	1	[25]
Other members	1½	[40]
Concrete not exposed to weather or in contact with ground:		
Slabs, walls, joists	¾	[20]
Beams, columns:		
Primary reinforcement	1½	[40]
Ties, stirrups or spirals	1	[25]
Shells, folded plate members:		
#6 [#19] and larger	d_b*	
#5 [#16] and smaller	⅜	[10]

* But not less than ¾ inches [20].

8.10.4 Corrosive Atmosphere or Severe Exposure

In corrosive atmospheres or severe exposure conditions, the amount of concrete protection should be suitably increased, and the denseness and nonporosity of the protecting concrete should be considered, or other protection should be provided.

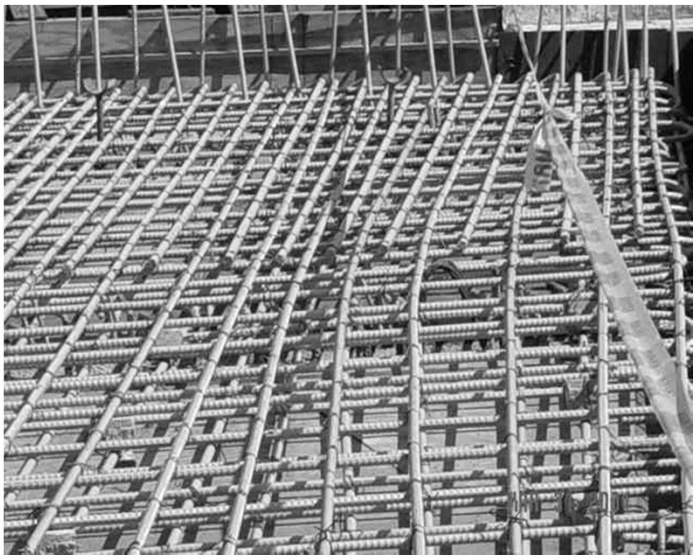
8.11 Field Cutting of Reinforcing Bars

Various means are used to cut reinforcing bars at the jobsite. The smaller size bars, #3 to #5 [#10 to #16], can usually be cut with bolt-cutters. All bar sizes can be cut with an abrasive saw or by flame-cutting such as using an oxy-acetylene torch.

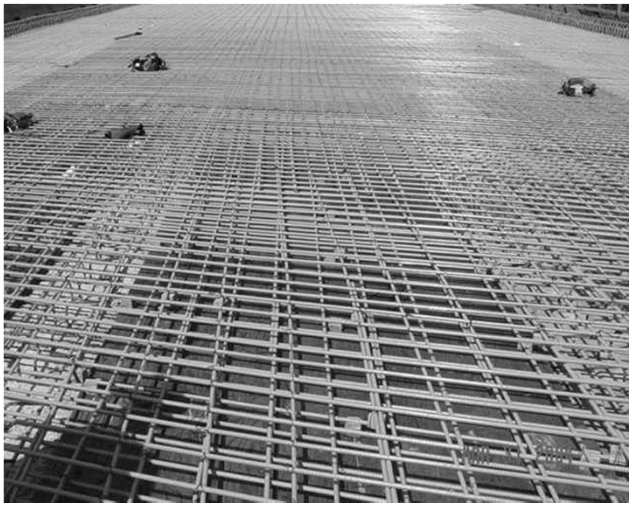
Regarding flame-cutting, tests have shown that any effect of flame-cutting is localized to the end-cut surfaces. Only a very short distance, approximately 3/16 inch [5 mm], from the flame-cut ends is affected. Hardness testing was used to evaluate the effects of flame-cutting on the tensile properties of the bars. From the tests it was concluded that flame-cutting had no adverse effects.

Flame-cutting of epoxy-coated reinforcing bars is not recommended.

Transverse Bar Alignment Shift?



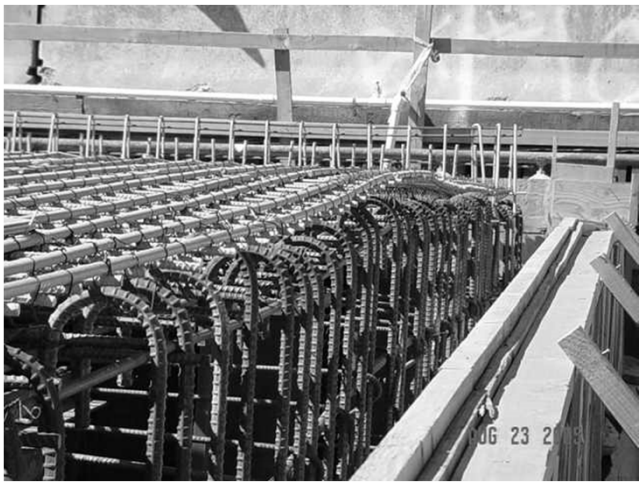
Longitudinal Bar Alignment Shift?



Bar Supports

Rail Stirrup Height Uneven?

Transverse Deck Bars Drop at Corner?

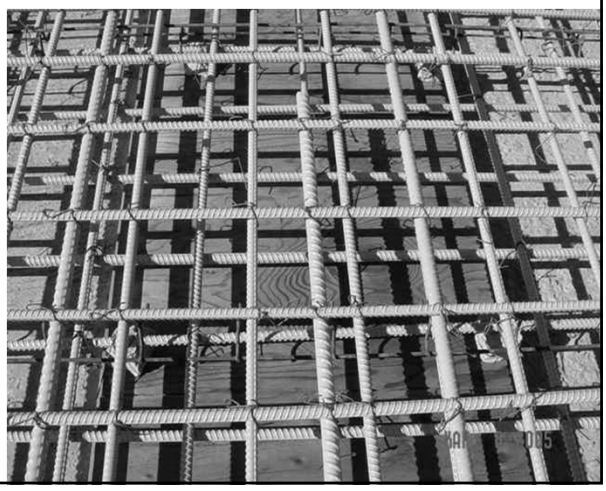


Bar Supports 530.41(b) & (c)

2′ Centers (plans)

Concrete blocks (Dobies) or other approved devices

No rocks, broken brick, or wood



Large Support Spacing Caused Epoxy Ties to Unzip

Ties

Ties
530.41(b)

Top mat of <u>footings</u> & <u>decks</u>:

Tie 100%

If spacing < 6″
Tie 50%

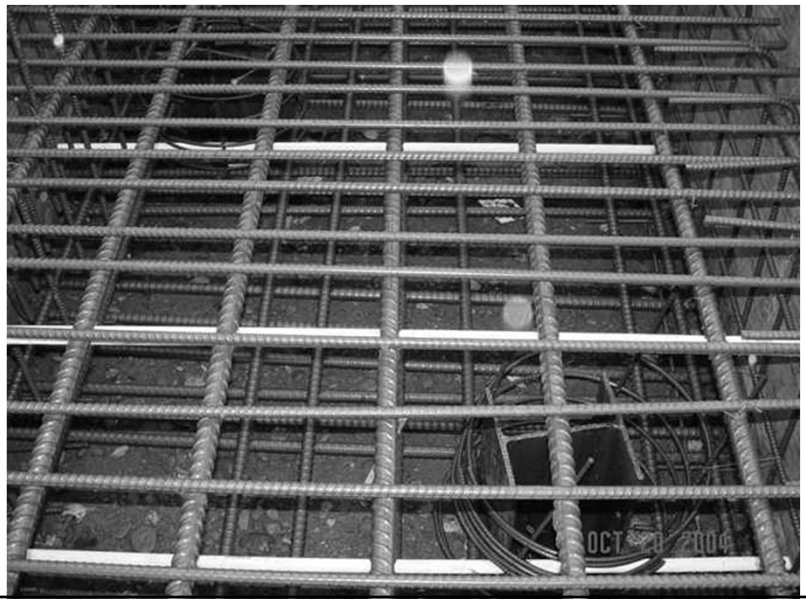
Other locations:

Tie 100%

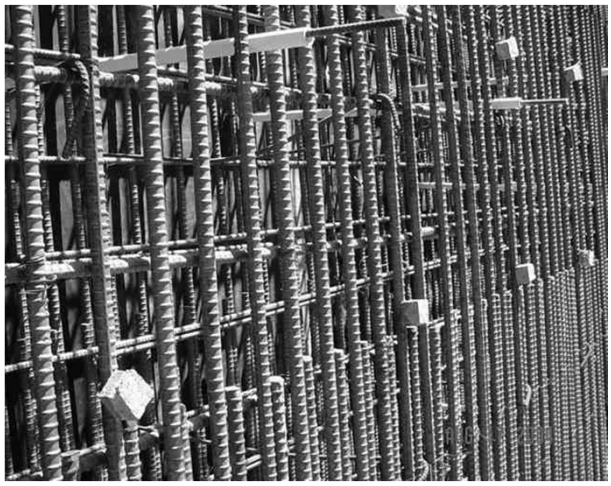
If spacing < 1′
Tie 50%

Epoxy coated ties for epoxy rebar

No Ties for Up to 10 Feet?

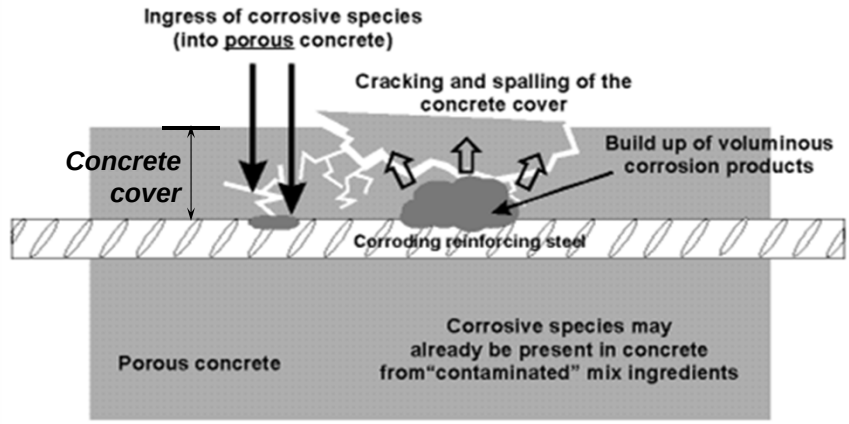


Missing Ties



Clearances

Concrete Cover Affects Rebar Corrosion



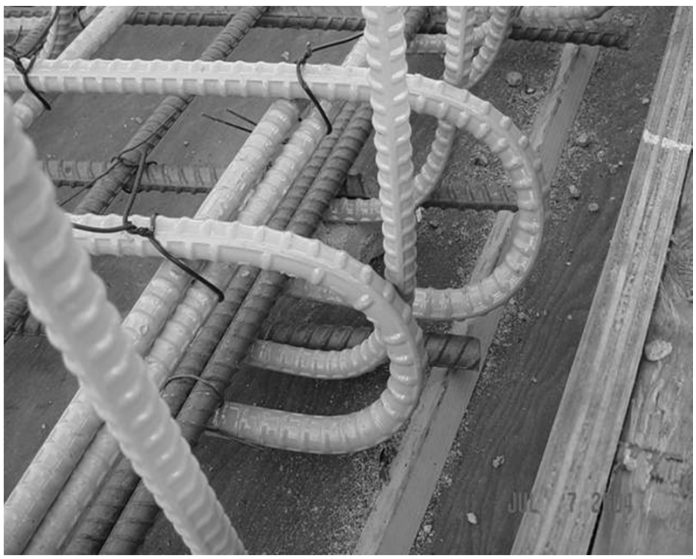
Clearances

- Within tolerances recommended in CRSI's Manual of Standard Practice, Chapter 8 unless otherwise specified.
  (00530.41)
- As specified on the plans.
- **Tolerance on top mat of reinforcement to the top of deck surface is (+/-) 1/4″.**

(00540.48(g))

Hooked Bar Laying on Form?

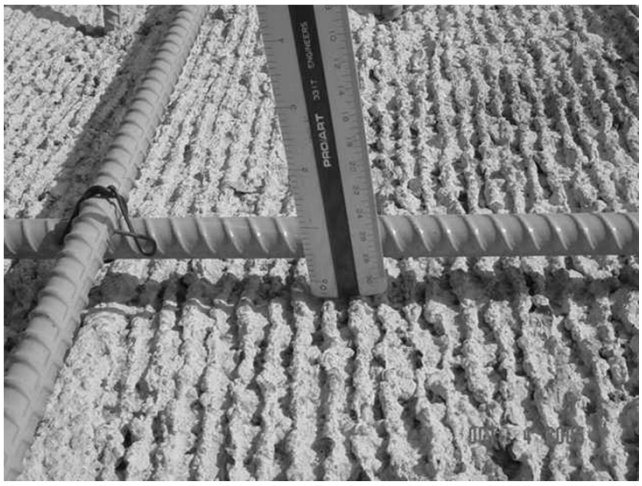
Transverse Bar on Chamfer Strip?



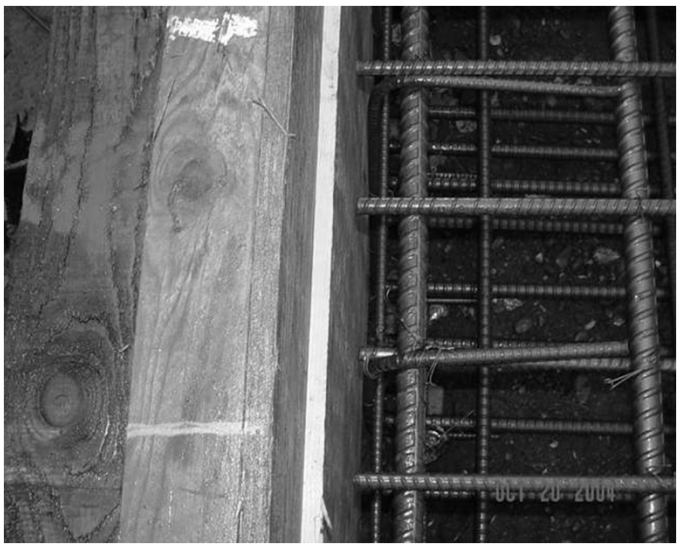
Transverse Deck Bar Under Drip Strip?

Transverse Bar Touching Fillet Form?

¾″ Clearance Under Deck Rebar Over Slabs?

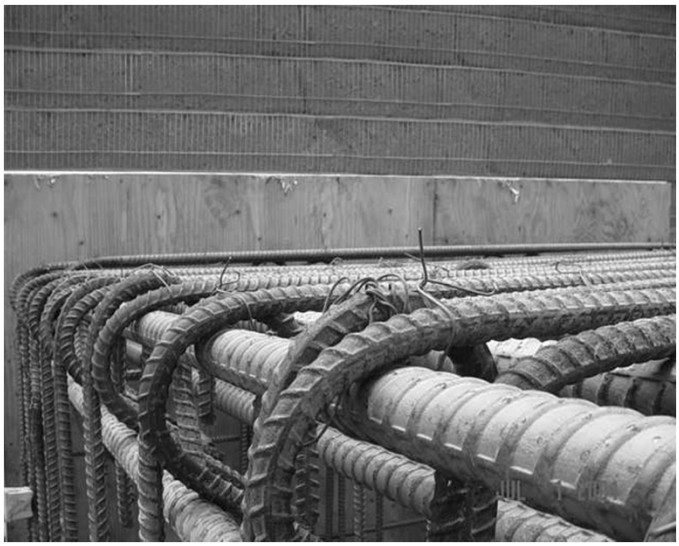


Bottom Transverse Bars in Pilecap Touching Forms?



Bar Touching Form in Crossbeam?

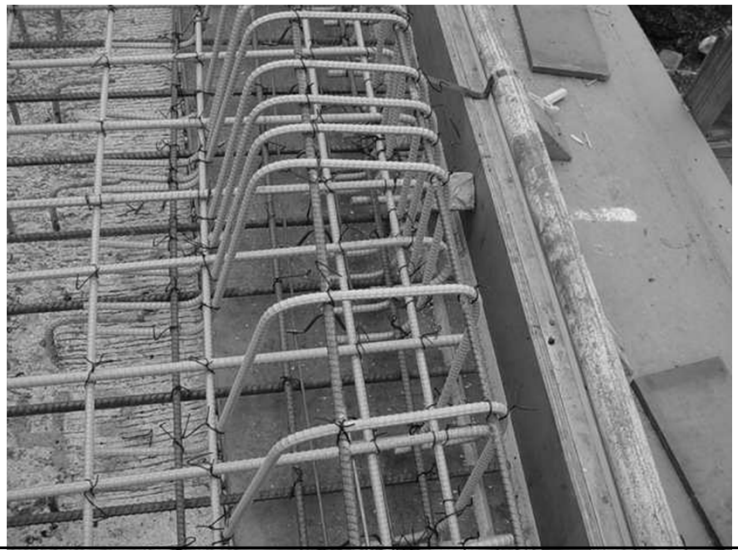
High Stirrup in Crossbeam?



Watch Clearances on Rail Windows

½″ Clearance on Vertical Rail Bars to Window Form

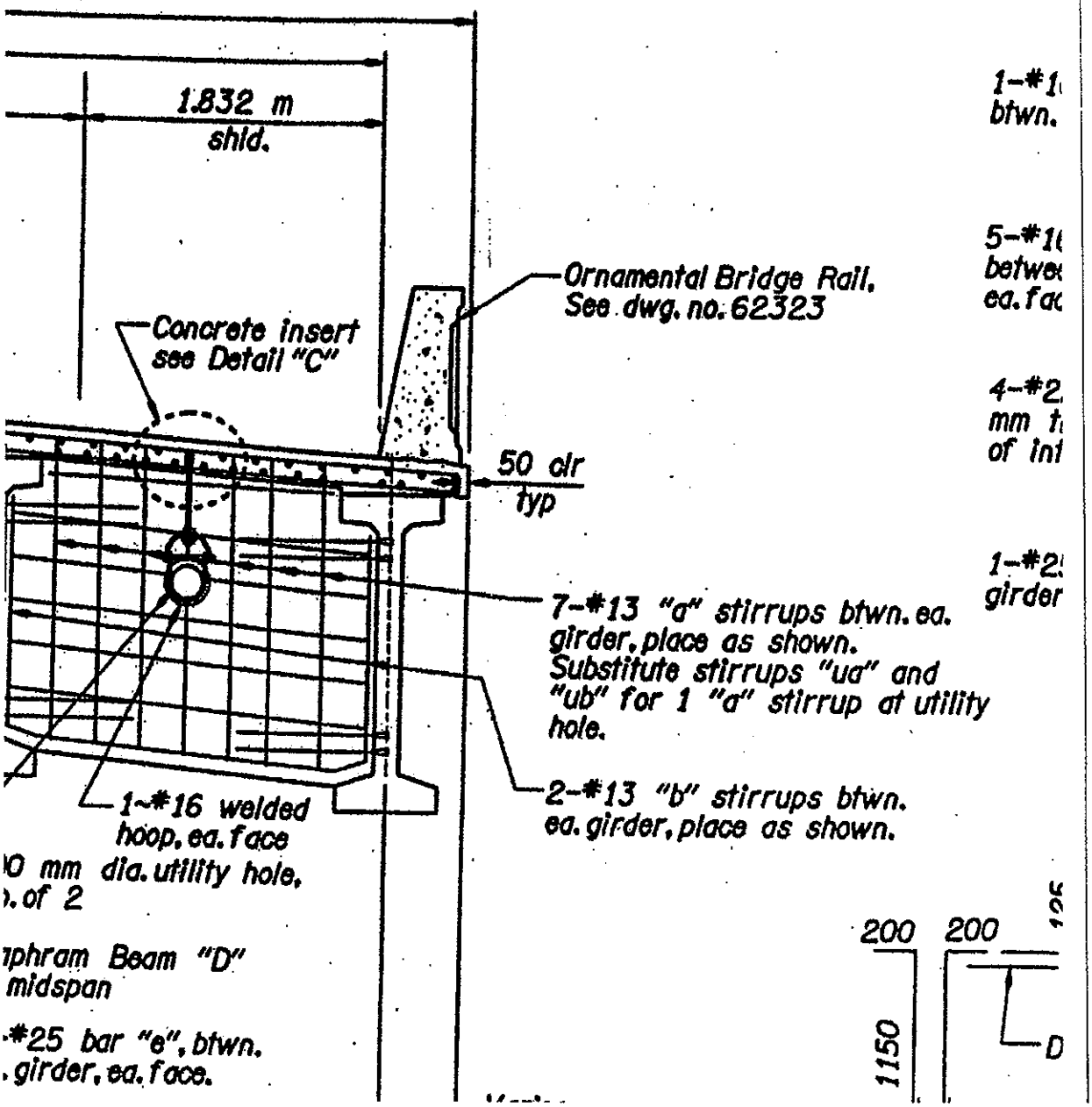
How far are rail stirrups from the deck side form?

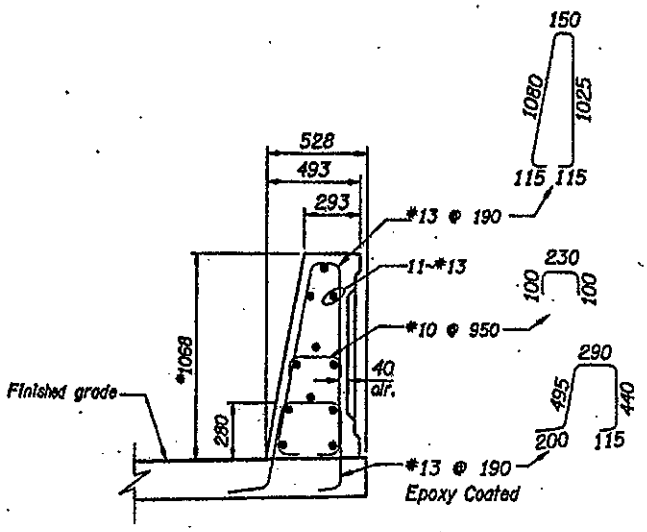


Clearance Exercise

Calculate the distance from the rail stirrups to the deck side form.

_____
_____
_____
_____


1.832 m
shld.
Concrete insert
see Detail "C"
Ornamental Bridge Rail,
See dwg. no. 62323
50 clr
typ
7-#13 "a" stirrups btwn. ea.
girder, place as shown.
Substitute stirrups "ua" and
"ub" for 1 "a" stirrup at utility
hole.
2-#13 "b" stirrups btwn.
ea. girder, place as shown.
1-#16 welded
hoop, ea. face
0 mm dia. utility hole,
. of 2
iphram Beam "D"
midspan
-#25 bar "e", btwn.
girder, ea. face.
Trans
Stop
of Be
1-#1
btwn.
5-#1
betwe
ea. fa
4-#2
mm t
of int
1-#2
girder
200
200
1150
D

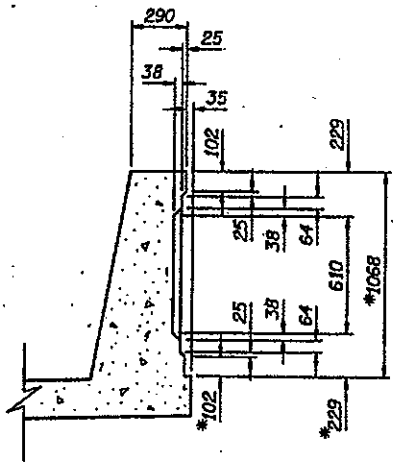


TYPICAL ORNAMENTAL RAIL SECTION

Scale: 1:15

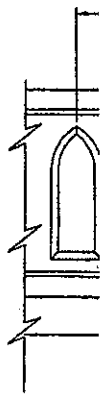
* Increase height of rail on end panel to allow for ACWS thickness.

NOTE:
For rail, rail joints, and rail transitio shown see std. dwg. no. BR200 and rail is similar to a Standard Type "



SECTION A-A

Scale: 1:15



ORI

NOTE: All dimensions are in millimeters (mm), all elevations and stations are in meters (m), except as noted.

TE	REVISION	BY

DRAFTED: James Johnson/D. Axtell

CHECKED: Sean White

REVIEWED: James Johnson

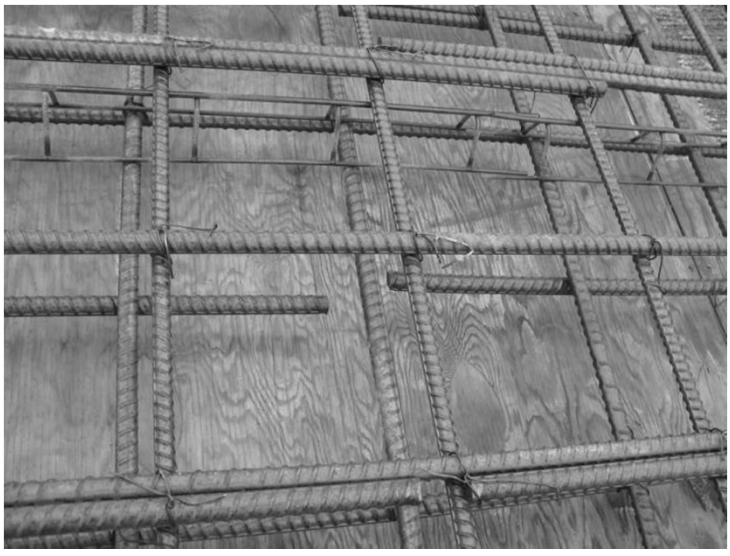
DESIGNER

EXPIRES: 12-31-23

OREGON DEPA
BRIDGE I

Splices

No Splice?



Splices

- As permitted per plans
- Splice bars No. 11 & smaller by Lapping or Approved Mechanical Splice.
- Splice bars No. 14 and larger with an Approved Mechanical Splice Only.
- Welded only with prior approval and with a certified welder.

Lap Splice
530.42(b)

- Place bars in contact.
- Fasten with 3 ties/splice minimum.
- Length as shown (General Notes).
- Epoxy coated reinforcement requires longer splice length.

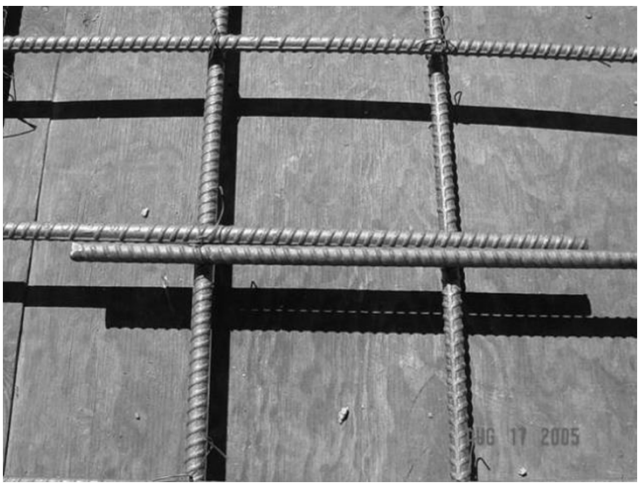
Reinforcing Splice Lengths (Class B) Grade 60 f'c = 3.3 ksi										
Bar Size	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14 & #18
Uncoated	1'-0"	1'-4"	1'-8"	2'-0"	2'-9"	3'-7"	4'-6"	5'-9"	7'-0"	Not permitted
Coated (1)	1'-2"	1'-7"	2'-0"	2'-5"	3'-3"	4'-3"	5'-5"	6'-10"	8'-5"	Not permitted
Coated (2)	1'-6"	2'-0"	2'-6"	3'-0"	4'-1"	5'-4"	6'-9"	8'-7"	10'-6"	Not permitted

Use Coated (1) for epoxy coated bars with cover at least $3*d_b$ and clear spacing between bars at least $6*d_b$.

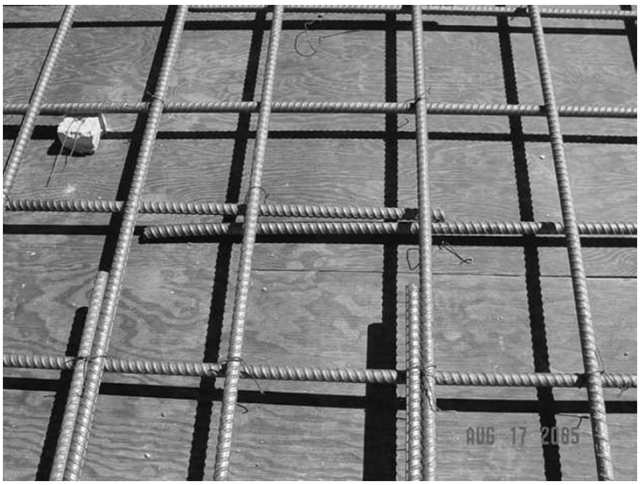
Use Coated (2) for epoxy coated bars with cover less than $3*d_b$ or clear spacing between bars less than $6*d_b$.

Increase all splice lengths 40% for horizontal or nearly horizontal bars so placed that more than 12" of fresh concrete is cast below the bar.

1 Tie on Splice?



1 Tie on Splice?



Mechanical Splice 530.42(c)

- Construct per Specifications and Manufacturers Recommendations.
- Construct test splices in the presence of the Engineer.
- Install splices in the presence of the Engineer. Splices made without the Engineer present will be rejected.

Mechanical Splice Installers 530.30

- Provide qualified mechanical splice installers.
- Construct test splices in the presence of the Engineer.
- Construct 3 splice samples per type and size for each installer.
- Do not begin splice installation until installers have been approved.

Spliced Bars Project Up?

Spliced Vertical Column Bars

Reinforcement Inspection

Inspection of the forms and reinforcement takes time.

Check early and often to help assure they are doing things correctly and to avoid minimal rework. Do not wait until just before the concrete placement.

Do a final check just prior to the concrete placement to assure everything still looks good.

Oregon Department of Transportation

Deck Rebar Checklist

Project Information

Project Name (Section) | Contract No.

Highway | Federal Aid No.

Contractor or Subcontractor

Deck Placement Date:

	Item	Inspected				Remarks
		Yes	No	N/A	Date (mm/dd/yyyy)	
1	Bottom Mat Bar Size & Spacing	☐	☐	☐		
2	Bottom Mat Ties @ 50%	☐	☐	☐		
3	Bottom Mat Clearance	☐	☐	☐		
4	Epoxy Ties (if epoxy bars)	☐	☐	☐		
5	Supports @ 2' Centers	☐	☐	☐		
6	Clearance @ Drip Strip	☐	☐	☐		
7	Lap Splices have three (3) ties	☐	☐	☐		
8	Top Mat Bar Size & Spacing	☐	☐	☐		
9a	Top Mat Ties @ 100% if spacing is greater than or equal to 6"	☐	☐	☐		
9b	Top Mat Ties @ 50% if spacing is less than 6"	☐	☐	☐		
10	Top Mat Bars directly over Bottom Mat Bars	☐	☐	☐		
11	Top & Bottom Mat Bars installed parallel to skewed joint at both ends of deck	☐	☐	☐		
12	Side & End Form Clearances	☐	☐	☐		
13	Rail Stirrup Size & Spacing	☐	☐	☐		
14	Additional Rail Stirrups @ Joints	☐	☐	☐		
15	Rail longitudinal bars cut at joint except bottom two	☐	☐	☐		
16	Rail 1-1/4" inside Edge of Deck	☐	☐	☐		
17	Rebar Support @ Corners	☐	☐	☐		
18	Dry Run Clearance Check	☐	☐	☐		

Remarks

Inspected by | Date

OREGON DEPARTMENT OF TRANSPORTATION

PREPOUR CHECKLIST

PROJECT NAME (SECTION)	CONTRACT NO.
HIGHWAY	FEDERAL AID NO.
CONTRACTOR OR SUBCONTRACTOR	

PLACEMENT:

	DATE	INITIALS	REMARKS
REINFORCEMENT			
FABRICATION			
INSTALLATION			
CLEARANCE			
FORMS			
DIMENSIONS			
CONST JOINTS			
IMBEDDED ITEMS			
BLOCKOUTS			
SURVEY/GRADE			
CONCRETE PLACEMENT			
PLACING METHOD			
QUANTITY			
POUR CREW			
VIBRATION			
LIFT SIZE			
WEATHER			
DURATION			START _____ FINISH _____
TESTING			
MIX DESIGN #			
QCT			
TEST RESULTS			
REJECTED LOADS			
REMARKS			

REMARKS

PREPARED BY:	WORK DATE:

OREGON DEPARTMENT OF TRANSPORTATION

PREPOUR CHECKLIST

PROJECT NAME (SECTION)	CONTRACT NO.
FORM SAMPLE	12345
HIGHWAY	**FEDERAL AID NO.**
THE DALLES - CALIFORNIA	BRF-RSTP-5004(32)
CONTRACTOR OR SUBCONTRACTOR	
JD CONTRACTORS, INC.	

PLACEMENT: BOTTOM SLAB POUR 3; SPANS 2/3 & 8/9

	DATE	INITIALS	REMARKS
REINFORCEMENT			
FABRICATION	2-29-00	BAP	MOSTLY STRAIGHT BARS, ALL CORRECT LENGTH
INSTALLATION	2-29-00	BAP	PLACED AS PER PLANS
CLEARANCE	2-29-00	BAP	40 CLEAR OF FORMS, TOO BETWEEN MATS
FORMS			
DIMENSIONS	3-13-00	BAP	
CONST JOINTS	3-13-00	BAP	SPAN 1/10 BUSH HAMMER & PRESS WASH, SPAN 3 & 8 SURFACE RETARDER
IMBEDDED ITEMS	3-13-00	BAP	VENT TUBES IN WING SECT & HIGH PT EACH SPAN
BLOCKOUTS	3-13-00	BAP	FALSWORK LOWERING & DRAIN HOLES
SURVEY/GRADE			
CONCRETE PLACEMENT			
PLACING METHOD	3-14-00	BAP	PUMP, 32m SCHWING - PCP
QUANTITY	3-14-00	BAP	250 m^3
POUR CREW	3-14-00	BAP	8 FINISHERS (LAROSO), 2 VIB (KPC)
VIBRATION	3-14-00	BAP	ONE HIGH CYCLE
LIFT SIZE	3-14-00	BAP	FULL DEPTH 250mm
WEATHER	3-14-00	BAP	FAIR, 50's (°F) & WINDY (10-15 MPH CONSISTANT)
DURATION			START _____ FINISH _____
TESTING			
MIX DESIGN #	3-14-00	BAP	2 M1 ROUND ROCK
QCT	3-14-00	BAP	DON BRANDON & MIKE LESVEQUE 2 M1
TEST RESULTS	3-14-00	BAP	AIR 6-7%, SLUMP 150 TO 175mm
REJECTED LOADS	3-14-00	BAP	NONE
REMARKS	3-14-00	BAP	VERY SMOOTH

REMARKS

FIRST USE OF ROUND ROCK CLASS 35 MIX. VERY CONSISTANT TESTING, SLUMPS SAME THRU LOADS. PUMPING VERY EASY. SCREEDING & FINISHING WENT VERY WELL. PLACED ABOUT 35m 3/HR, 9 HRS TOTAL TIME.

PREPARED BY:	WORK DATE:
IM INSPECTOR	6-26-06