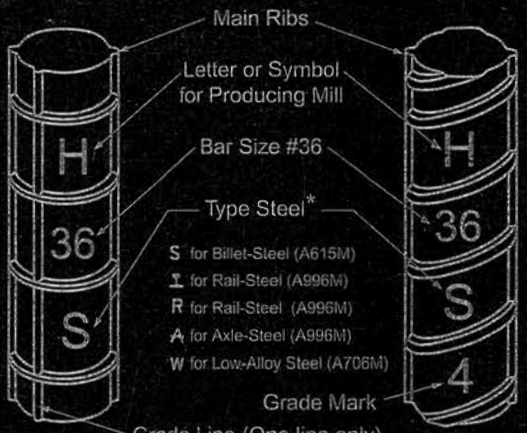
SECOND PRINTING

MSP-2-01



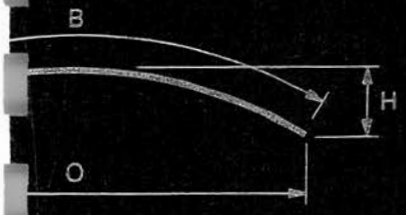
MANUAL OF STANDARD PRACTICE

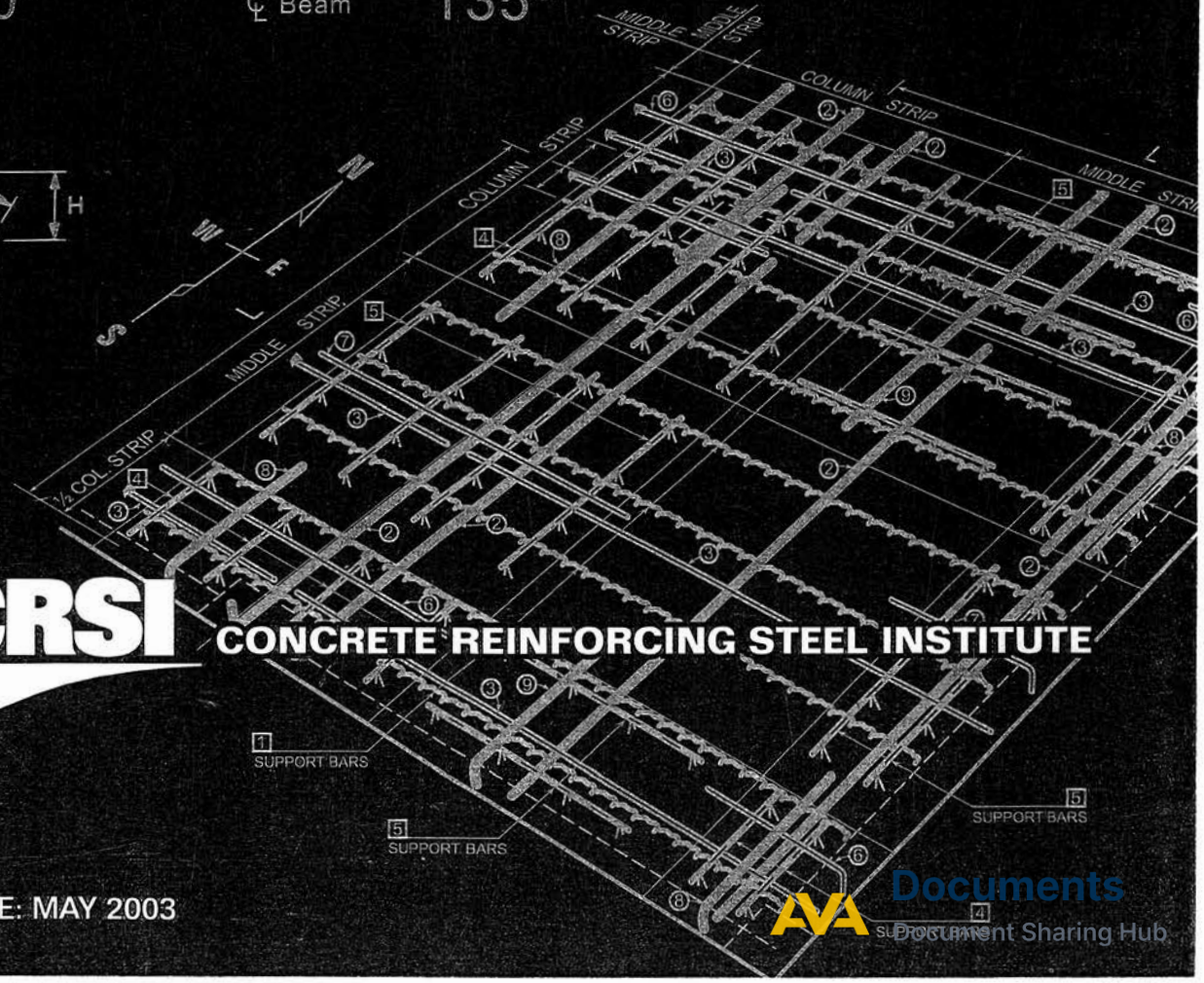


*Bars marked with an S and W meet both A615 and A706

GRADE 420







CRSI CONCRETE REINFORCING STEEL INSTITUTE

DATE: MAY 2003

AVA Documents Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

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.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

MANUAL OF STANDARD PRACTICE

27th Edition, 2001
Second Printing, 2003
Prepared under the Direction of
the CRSI Committee on Engineering Practice by the
Committee on Manual of Standard Practice

David F. Horton, Chairman (Barker Steel Company, Inc.)
Robert Orcutt, Vice-Chairman (Rio Grande Rebar Services Div.)
Stanley D. Agee, Secretary (PIERESEARCH)
Derrell E. Bain (Dayton/Richmond)
Charles H. Beutnagel (Capitol City Steel Company, Inc.)
Carlos A. Bonacich (The Lofland Company of New Mexico)
Steve Brown (Dayton/Richmond)
Lee Buchholz (Ambassador Steel Corporation)
Larry Campbell (Rebar Services & Supply Co.)
James A. Carr (RESCO Steel Products Corporation)
Ian Chambers (CADS)
Larry Ciarkowski (The Lofland Company)
Steve Collar (Viking Steel, Inc.)
Charles Davidson (Rockford Fabricators, Inc.)
Luis D. Del Rosario (TAMCO)
John R. Deubert (Fox-Howlett Industries)
Gustav G. Erlemann (Consultant)
Ronald D. Flach (Titusville Fabricators, Inc.)
Dennis J. Fontenot (Capitol City Steel Company, Inc.)
David A. Grundler Jr. (Applied Systems Associates, Inc.)
Jimmy D. Hahs (East Tennessee State University)
Jay A. Hetherington (Structural Metals, Inc.)
Dennis L. Hunter (AmeriSteel)
Blake Irwin (The Lofland Company)
Dale Jordan (Free State Steel, Inc.)
Mike Kozacek (Potter Form & Tie Co.)
Harry B. Lancelot III (Dayton/Richmond)
Marty E. Lancial (Aztec)
Wayne Lewis (Amber Steel Company)
Ron Malo (Dominion Rebar Company)
Ron McCleary (Ambassador Steel Corporation)
Peter Meza (PM Consulting)
Brett Moran (Cargill Steel & Wire)
Eli Nabors (Dalco Industries, Inc.)
Mark D. Newman (CoMet Steel, Inc.)
Paul L. Nims (Structural Metals, Inc.)
Ray Nix (F. J. Folz Co., Inc.)
Steve Noll (Contractors Steel Corporation)
John R. Paine Jr. (Dayton/Richmond)
Taylor K. Ranker (Teton Steel)
Roy H. Reiterman (Wire Reinforcement Institute)
Scott Richardson (SMI Rebar-North Carolina)
Greg Rohm (SMI Rebar-Virginia)
Thomas G. Schmaltz (Precision ReBar & Accessories, Inc.)
B. Scott Striebinger (Eastern Steel Constructors, Inc.)
John J. Tekus (Akron Rebar Company)
Thomas Terry (CoMet Steel, Inc.)
Dale Thomas (SMI Rebar-South Carolina)
Johnnie B. Thompson (Rebar Services & Supply Co.)
David Vout (CADS-USA, Inc.)
Anthony L. Felder, Editor (Concrete Reinforcing Steel Institute)

FOREWORD

The recommendations in this Manual concerning the selection and use of reinforcing materials **should not be substituted for the judgment of an experienced Architect/Engineer** as to the best way of achieving specific design requirements.

This Manual, first published in 1939, was prepared and periodically revised by the Engineering Practice Committee of the Concrete Reinforcing Steel Institute. Recommendations based upon their nationwide composite experience are presented here as a guide to reinforcing materials available and industry practices of estimating, detailing, fabricating, placing and contracting for reinforcing materials. To facilitate the Architect/Engineer's function, and to ensure an accurate interpretation of the requirements, it is suggested that the recommended industry practices herein be included by reference in the project drawings or project specifications. In the absence of specifications to the contrary, it is intended that these recommended industry practices govern the interpretation of contracts entered into between the Buyer and Seller of reinforcing steel and related materials. The Institute believes that use of these recommendations from design through construction will produce maximum economy in the final reinforced concrete structure to the benefit of all concerned.

This Manual should serve a twofold purpose:

1) To delineate as precisely as possible the industry practices for reinforcing steel.

2) To provide a convenient reference source for the Architect/Engineer, the Inspector, the Detailer and Fabricator.

In this Manual, the terms "ACI Building Code," "ACI 318," "ACI Code," etc., refer to "Building Code Requirements for Structural Concrete (ACI 318-99)" as issued by the American Concrete Institute.

PRINTED IN THE UNITED STATES OF AMERICA
This book, or parts thereof, may not be reproduced in any form without permission of the Concrete Reinforcing Steel Institute
©2001—Concrete Reinforcing Steel Institute
AVA Documents Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

Inch-Pound and Metric Units

This 27th edition of the Manual includes, for the first time, metric units in conjunction with inch-pound units. Inch-pound units in the text and tables are followed by metric units enclosed within brackets.

Soft Metric Reinforcing Bars

It is important for users of this Manual to be aware of current industry practice regarding soft metric reinforcing bars. The term "soft metric" is used in the context of bar sizes and bar size designations. "Soft metric conversion" means describing the nominal dimensions of inch-pound reinforcing bars in metric units, but not physically changing the bar sizes. In 1997, producers of reinforcing bars (the steel mills) began to phase in the production of soft metric bars. Within a few years, the shift to exclusive production of soft metric reinforcing bars was essentially achieved. Virtually all reinforcing bars currently produced and used in the USA are soft metric. The steel mills' initiative of soft metric conversion enables the industry to furnish the same reinforcing bars to inch-pound construction projects as well as to metric construction projects, and eliminates the need for the steel mills and fabricators to maintain a dual inventory. Thus, USA-produced reinforcing bars furnished to any construction project most likely will be soft metric.

Designations of Bar Sizes. The sizes of soft metric reinforcing bars are physically the same as the corresponding sizes of inch-pound bars. Soft metric bar sizes, which are designated #10, #13, #16, and so on, correspond to inch-pound bar sizes #3, #4, #5, and so on. The metric bar designations are simply a re-labeling of the inch-pound bar designations. The following table shows the one-to-one correspondence of the soft metric bar sizes to the inch-pound bar sizes.

Soft Metric Bar Sizes vs. Inch-Pound Bar Sizes

Soft Metric Bar Size Designation	Inch-Pound Bar Size Designation
#10	#3
#13	#4
#16	#5
#19	#6
#22	#7
#25	#8
#29	#9
#32	#10
#36	#11
#43	#14
#57	#18

Minimum Yield Strengths or Grades. Virtually all steel mills in the USA are currently producing reinforcing bars to meet the metric requirements of the ASTM specifications. Minimum yield strengths in metric units are 300, 350, 420 and 520 MPa (megapascals), which are equivalent to 40,000, 50,000, 60,000 and 75,000 psi, respectively. Metric Grade 420 is the counterpart of standard Grade 60.

Bar Marking. Soft metric reinforcing bars are required to be identified with the Producer's mill designation, bar size, type of steel, and minimum yield strength or grade. For example, consider the marking requirements for a #25, Grade 420 metric bar, which is the counterpart of an inch- pound #8, Grade 60 bar. Regarding the bar size and grade, the ASTM specifications require the number "25" to be rolled onto the surface of the metric bar to indicate its size. For identifying or designating the yield strength or grade, the ASTM specifications provide an option. A mill can choose to roll a "4" (the first digit in the grade number) onto the bar, or roll an additional longitudinal rib or grade line to indicate Grade 420.

Chapter 1 in this Manual includes a detailed presentation of the inch-pound and metric requirements in the ASTM specifications for reinforcing bars. Appendix A shows the bar marks used by USA producers to identify Grade 420 soft metric bars. More information about soft metric reinforcing bars is given in Engineering Data Report No. 42, "Using Soft Metric Reinforcing Bars in Non-Metric Construction Projects". EDR No. 42 can be found on CRSI's Website at **www.crsi.org.**

Users of this Manual are also encouraged to visit the CRSI Website for:

- Descriptions of CRSI publications and software, and ordering information
- Institute documents available for downloading
- Technical information on epoxy-coated reinforcing bars
- Technical information on continuously reinforced concrete pavement
- Membership in CRSI and member web links
- General information on the CRSI Foundation
- Information on the CRSI Design Awards competition

AVA Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

TABLE OF CONTENTS

PAGES

CHAPTER 1—MATERIAL SPECIFICATIONS FOR REINFORCING BARS **1-1 to 1-5**

1.1. Introduction 1-1
1.2. Reinforcing Bars 1-1
1.3. ACI Building Code—Requirements for Reinforcing Bars 1-1
1.4. Coated Reinforcing Bars for Corrosion Protection 1-1
1.5. Spiral Reinforcement 1-3
1.6. Welding of Reinforcing Bars 1-3
1.7. Identification Marks—ASTM Standard Reinforcing Bars 1-4

CHAPTER 2—WELDED WIRE FABRIC (WWF) **2-1 to 2-10**

2.1. Introduction 2-1
2.2. ASTM Specifications 2-1
2.3. Style Identification 2-1
2.4. Specifying Welded Wire Fabric 2-1
2.5. Detailing Welded Wire Fabric 2-1
2.6. ASTM Specification for Epoxy-Coated Wire and Welded Wire Fabric 2-2
2.7. Handling, Shipping and Unloading Welded Wire Fabric 2-10

CHAPTER 3—BAR SUPPORTS **3-1 to 3-17**

3.1. Introduction 3-1
3.2. Wire Bar Supports 3-1
3.3. Precast Concrete Bar Supports 3-3
3.4. All-Plastic Bar Supports 3-3
3.5. Side-Form Spacers 3-3
3.6. Recommendations for Bar Supports for Epoxy-Coated Reinforcing Bars 3-3
3.7. Placing Bar Supports 3-8
3.8. One-Way Solid Slabs 3-9
3.9. Joists 3-10
3.10. Beams and Girders 3-10
3.11. Sequence of Placing Bar Supports and Reinforcing Bars in Two-Way Flat Plate 3-11
3.12. Sequence of Placing Bar Supports and Reinforcing Bars in Two-Way Flat Slab 3-12
3.13. Sequence of Placing Bar Supports and Reinforcing Bars in Two-Way Waffle Flat Slab 3-13
3.14. Bar Supports for Special Conditions 3-14
3.15. Bar Supports for Highway Bridge Slab Reinforcement 3-16

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

TABLE OF CONTENTS

PAGES

CHAPTER 4—NOTES TO ARCHITECT/ENGINEER 4-1 to 4-11

4.1. Introduction . . . 4-1
4.2. Recommended Industry Practices . . . 4-1
4.3. Sizes of Reinforcing Bars and Spirals . . . 4-1
4.4. Grade or Minimum Yield Strength Designation . . . 4-1
4.5. Standard Notation . . . 4-1
4.6. Project Drawings . . . 4-2
4.7. Length of Reinforcing Bars . . . 4-2
4.8. Beams and Girders . . . 4-3
4.9. Joist Construction . . . 4-3
4.10. Flat Plates and Flat Slabs . . . 4-3
4.11. Post-Tensioned Beams and Slabs . . . 4-3
4.12. Falsework and Form Reuse . . . 4-3
4.13. Columns . . . 4-3
4.14. Structural Integrity . . . 4-4
4.15. Splices . . . 4-4
4.16. Designing with Coated Reinforcing Bars . . . 4-5
4.17. Project Specifications Provisions for Coated Reinforcing Bars . . . 4-5
4.18. Fabrication of Reinforcing Bars . . . 4-6
4.19. Placing Drawings . . . 4-6
4.20. Special Services and Items . . . 4-7
4.21. Field Cutting of Reinforcing Bars . . . 4-7
Suggested Specifications for Reinforcing Steel . . . 4-8

CHAPTER 5—RECOMMENDED INDUSTRY PRACTICE FOR ESTIMATING REINFORCING MATERIALS AND SERVICES 5-1 to 5-6

5.1. Introduction . . . 5-1
5.2. Scope . . . 5-1
5.3. General . . . 5-1
5.4. Fabrication . . . 5-1
5.5. Extras . . . 5-1
5.6. Radial Prefabrication (Bend Type 9) . . . 5-2
5.7. Standard Hooks . . . 5-2
5.8. Splicing of Bars . . . 5-3
5.9. Bar Dimensions . . . 5-3
5.10. Spiral Reinforcement and Spacers . . . 5-4
5.11. Temperature-Shrinkage Reinforcement . . . 5-5
5.12. Slab, Wall, or Footing Bar Spacing . . . 5-5
5.13. Joists Adjoining Beams or Walls . . . 5-5
5.14. Corner Bars . . . 5-5
5.15. Bar Supports . . . 5-5
5.16. Side-Form Spacers . . . 5-5
5.17. Welded Plain or Deformed Wire Fabric . . . 5-6
5.18. Post-Tensioned Construction . . . 5-6

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

TABLE OF CONTENTS

PAGES

CHAPTER 6—RECOMMENDED INDUSTRY PRACTICE FOR DETAILING REINFORCING MATERIALS 6-1 to 6-7

6.1. Introduction 6-1
6.2. Technical Service by Seller 6-1
6.3. Performance—Placing Drawings 6-1
6.4. Miscellaneous Detailing Practices 6-1
6.5. Overall Diameter of Bars 6-2
Standard Hooks 6-5
6.6. Reinforcing Bars for Masonry Construction 6-6

CHAPTER 7—RECOMMENDED INDUSTRY PRACTICE FOR FABRICATION OF REINFORCING MATERIALS AND SERVICES 7-1 to 7-8

7.1. Introduction 7-1
7.2. Quality and Inspection 7-1
7.3. Bending 7-1
7.4. Standard Bundling and Tagging 7-1
7.5. Special Bundling and Tagging 7-1
7.6. Standard Fabrication 7-1
7.7. Special Fabrication 7-2
7.8. Radial Prefabrication 7-2
7.9. Spirals 7-2
7.10. Loading Limits 7-2
7.11. Extra Work or Materials 7-3
7.12. Special Services 7-3
7.13. Special Items 7-3

CHAPTER 8—RECOMMENDED INDUSTRY PRACTICE FOR PLACING REINFORCING BARS 8-1 to 8-4

8.1. Introduction 8-1
8.2. General 8-1
8.3. Surface Condition of Reinforcing Bars 8-1
8.4. Field Bending of Reinforcing Bars 8-1
8.5. Spacing of Reinforcing Bars 8-1
8.6. Splices in Reinforcing Bars 8-1
8.7. Embedment and Extensions 8-2
8.8. Tolerances in Placement 8-2
8.9. Bar Supports 8-2
8.10. Concrete Protection for Reinforcing Bars 8-2
8.11. Field Cutting of Reinforcing Bars 8-4

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

TABLE OF CONTENTS

PAGES

CHAPTER 9—RECOMMENDED INDUSTRY PRACTICE FOR CONTRACT COMPONENTS **9-1 to 9-5**

9.1. Preface 9-1
9.2. Material Supply Contract 9-1
9.3. Material Supply and Installation Contract 9-3

CHAPTER 10—RECOMMENDED INDUSTRY PRACTICE FOR CONCRETE JOIST CONSTRUCTION **10-1 to 10-4**

10.1. Introduction 10-1
10.2. Design 10-1
10.3. Recommended Industry Practice 10-1

APPENDICES

A. U.S. Manufacturers of Grade 60 [420] Concrete Reinforcing Bars . . . . . **A-1 to A-8**

B. Simplified Practice Recommendation—Steel Spirals for Reinforced Concrete Columns . . . . . **B-1 to B-2**

C. Recommendations for Spacings of Bars in Slabs, Walls, or Footings . . . . . **C-1 to C-4**

D. Notes on Metrication . . . . . **D-1 to D-5**

E. References . . . . . **E-1 to E-2**

F. Corporate Members of the Concrete Reinforcing Steel Institute . . . . . **F-1 to F-3**

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 1

MATERIAL SPECIFICATIONS FOR REINFORCING BARS

1.1. Introduction

The standard specifications for steel reinforcement published by the American Society for Testing and Materials (ASTM) are generally accepted for construction in the United States. When ASTM revises these specifications, most authorities usually accept the latest ASTM specifications even when building codes or project specifications have not had corresponding revisions incorporated. This lag between changes and the special requirements of some public agencies causes occasional variations.

From the materials listed in this chapter, the Architect/Engineer should select the grade (minimum yield strength) and type of reinforcement which will best meet the specific design requirements.

1.2. Reinforcing Bars

Specifications for billet-steel, low-alloy steel, rail-steel, and axle-steel reinforcing bars are available from ASTM.

Tables 1-1, 1-2, and 1-3 summarize the pertinent tensile and bending, deformation, and chemical composition requirements for billet-steel and low-alloy steel reinforcing bars. Table 1-1 also lists the grades and bar sizes covered by the two most widely used ASTM specifications.

Producing mill identification marks required by the ASTM specifications are shown in Section 1.7 of this chapter. The bar marks used by American mills known to be commercially producing Grade 60 [420] rebars are illustrated in detail in Appendix A.

1.3. ACI Building Code—Requirements for Reinforcing Bars

The current ACI Building Code requires billet-steel and low-alloy steel reinforcing bars to conform to ASTM specifications A615/A615M and A706/A706M, respectively. Reinforcing bars conforming to ASTM A706/A706M are recommended for use in seismic-resistant reinforced concrete structures where controlled tensile properties are required, or for applications involving extensive welding. The ACI Building Code requires rail-steel and axle-steel reinforcing bars to also conform to ASTM specification A996/A996M.

1.4. Coated Reinforcing Bars for Corrosion Protection

The ACI Building Code permits the use of coated reinforcing bars as a corrosion-protection system. The Code requires epoxy-coated reinforcing bars to conform to the ASTM A775/A775M or A934/A934M specifications. Zinc-coated (galvanized) reinforcing bars must conform to ASTM A767/A767M. The bars that are to be epoxy-coated or zinc-coated (galvanized) must meet the Code's requirements for uncoated bars .

The ASTM A775/A775M specification for epoxy-coated reinforcing bars includes requirements for the epoxy coating material; surface preparation of the bars prior to application of the coating; the method of application of the coating material; limits on coating thickness; and acceptance tests to assure that the coating was properly applied. Epoxy-coated bars conforming to the ASTM A775/A775M specification are usually fabricated after application of the epoxy coating. All damaged areas of coating on the bars, which occur during fabrication and handling prior to shipment to the job-site, must be properly repaired (touched-up) with patching material.

ASTM A934/A934M prescribes requirements for epoxy-coated reinforcing bars that are prefabricated prior to application of the epoxy coating. The specification includes requirements for the epoxy coating material, surface preparation of the bars before coating, method of coating application, limits on coating thickness, and acceptance tests.

The ASTM A767/A767M specification for zinc-coated (galvanized) reinforcing bars includes requirements for the zinc coating material; the galvanizing process; the class or weight of coating; finish and adherence of the coating; and fabrication. Reinforcing bars are usually galvanized after fabrication. The specification prescribes minimum finished bend diameters for bars that are fabricated before galvanizing. Smaller finished bend diameters are permitted if the bars are stress-relieved. Thus, when bars are galvanized after fabrication, the Architect/Engineer should specify which bars require special finished bend diameters, usually the smaller bar sizes for stirrups and ties. The specification has two classes of zinc coating weights which are designated as Class I and Class II. Class I coating, which requires a zinc coating weight of 3.5 oz/ft^2 [1070 g/m^2], is normally specified for general construction.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 1

MATERIAL SPECIFICATIONS FOR REINFORCING BARS

TABLE 1-1 ASTM SPECIFICATIONS—BAR SIZES, GRADES, AND TENSILE AND BENDING REQUIREMENTS

Type of Steel and ASTM Specification	Bar Sizes	Grade	Minimum Yield Strength, psi [MPa]	Minimum Tensile Strength, psi [MPa]	Minimum Percentage Elongation in 8 in. [203.2 mm]	Bend Test Pin Diameter (d = nominal diameter of specimen)
Billet-Steel A615/A615M	#3 to #6 [#10 to #19]	40 [300]	40,000 [300]	70,000 [500]	#3 [#10] . . . . . 11 #4, #5, #6 [#13, #16, #19] 12	#3, #4, #5 [#10, #13, #16] . . . . . 3½d #6 [#19] 5d
	#3 to #18 [#10 to #57]	60 [420]	60,000 [420]	90,000 [620]	#3, #4, #5, #6 [#10, #13, #16, #19] . . . . . 9 #7, #8 [#22, #25] . . . . . 8 #9, #10, #11, #14, #18 [#29, #32, #36, #43, #57]. 7	#3, #4, #5 [#10, #13, #16] . . . . . 3½d #6, #7, #8 [#19, #22, #25] . . . . . 5d #9, #10, #11 [#29, #32, #36] . . . . . 7d #14, #18 (90°) [#43, #57 (90°)] 9d
	#6 to #18 [#19 to #57]	75 [520]	75,000 [520]	100,000 [690]	#6, #7, #8 [#19, #22, #25] . . . . . 7 #9, #10, #11, #14, #18 [#29, #32, #36, #43, #57]. 6	#6, #7, #8 [#19, #22, #25] . . . . . 5d #9, #10, #11 [#29, #32, #36] . . . . . 7d #14, #18 (90°) [#43, #57 (90°)] 9d
Low-Alloy Steel A706/A706M	#3 to #18 [#10 to #57]	60 [420]	60,000 [420]	80,000 [550]	#3, #4, #5, #6 [#10, #13, #16, #19] . . . . . 14 #7, #8, #9, #10, #11 [#22, #25, #29, #32, #36]. . . . . 12 #14, #18 [#43, #57] 10	#3, #4, #5 [#10, #13, #16] . . . . . 3d #6, #7, #8 [#19, #22, #25] . . . . . 4d #9, #10, #11 [#29, #32, #36] . . . . . 6d #14, #18 [#43, #57] 8d

For low-alloy steel reinforcing bars, the ASTM A706/A706M specification prescribes a maximum yield strength of 78,000 psi [540 MPa] and tensile strength must be 1.25 times the actual yield strength.

Bend tests are 180° except ASTM A615/A615M permits 90° for bar sizes #14 and #18 [#43 and #57].

TABLE 1-2 ASTM SPECIFICATIONS—DEFORMATION REQUIREMENTS

Bar Size	Maximum Average Spacing, in. [mm]	Minimum Average Height, in. [mm]	Maximum[1], Gap, in. [mm]
#3 [#10] #4 [#13] #5 [#16]	0.262 [6.7] 0.350 [8.9] 0.437 [11.1]	0.015 [0.38] 0.020 [0.51] 0.028 [0.71]	0.143 [3.6] 0.191 [4.9] 0.239 [6.1]
#6 [#19] #7 [#22] #8 [#25]	0.525 [13.3] 0.612 [15.5] 0.700 [17.8]	0.038 [0.97] 0.044 [1.12] 0.050 [1.27]	0.286 [7.3] 0.334 [8.5] 0.383 [9.7]
#9 [#29] #10 [#32] #11 [#36]	0.790 [20.1] 0.889 [22.6] 0.987 [25.1]	0.056 [1.42] 0.064 [1.63] 0.071 [1.80]	0.431 [10.9] 0.487 [12.4] 0.540 [13.7]
#14 [#43] #18 [#57]	1.185 [30.1] 1.58 [40.1]	0.085 [2.16] 0.102 [2.59]	0.648 [16.5] 0.864 [21.9]

[1]Chord of 12.5% of nominal perimeter

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 1

MATERIAL SPECIFICATIONS FOR REINFORCING BARS

TABLE 1-3 ASTM SPECIFICATIONS—CHEMICAL COMPOSITION REQUIREMENTS

Type of Steel and ASTM Designation	Condition*	Element									
		Carbon (C)	Manganese (Mn)	Phosphorus (P)	Sulfur (S)	Silicon (Si)	Copper (Cu)	Nickel (Ni)	Chromium (Cr)	Molybdenum (Mo)	Vanadium (V)
Billet-Steel A615/A615M	1	X	X	X	X						
	2			0.06%							
	3			0.075%							
Low-Alloy Steel A706/706M	1	X	X	X	X	X	X	X	X	X	X
	2	0.30%	1.50%	0.035%	0.045%	0.50%					
	3	0.33%	1.56%	0.043%	0.053%	0.55%					

*Condition Definitions: 1 Analysis required of these elements for each heat.
2 Maximum allowable chemical content for each heat.
3 Maximum allowable chemical content for finished bar.

1.5. Spiral Reinforcement

1.5.1 Standard Sizes

Plain bars, deformed bars, or wire for spirals are furnished in the following standard sizes and cross-sectional areas as prescribed in the "Simplified Practice Recommendation—Steel Spirals for Reinforced Concrete Columns" in Appendix B. Areas and weights are in accordance with the following:

Standard Sizes	Area, in.^{2} [mm^2]	Weight [Mass], lb/ft [kg/m]
3/8 in. or #3 [10 mm or #10]	0.11 [71]	0.376 [0.560]
1/2 in. or #4 [13 mm or #13]	0.20 [129]	0.668 [0.994]
5/8 in. or #5 [16 mm or #16]	0.31 [199]	1.043 [1.552]
3/4 in. or #6 [19 mm or #19]	0.44 [284]	1.502 [2.235]

1.5.2 Material

Reinforcing bars for spirals, plain or deformed, should conform to ASTM A615/A615M, or to ASTM A706/A706M, as specified on the project drawings or in the project specifications.

Plain wire for spirals should conform to ASTM A82 with a minimum yield strength of 70,000 psi [485 MPa].

Deformed wire for spirals should conform to ASTM A496 with a minimum yield strength of 75,000 psi [515 MPa].

Unless otherwise specified on the project drawings or in the project specifications, plain or deformed bars will be furnished.

1.6. Welding of Reinforcing Bars

1.6.1 Material Specifications and Welding Code

The "weldability" of steel, which is established by its chemical analysis, sets the minimum preheat and interpass temperatures, and limits the applicable welding procedures.

Low-alloy steel reinforcing bars, conforming to the ASTM A706/A706M specification, are intended for welding. Weldability is accomplished in the specification by limits or controls on the chemical composition of the steel. One limit is on individual chemical elements, for example, carbon is limited to a maximum of 0.30% and manganese to a maximum of 1.50%. Another limit is on "carbon equivalent." The term "carbon equivalent," abbreviated as C.E., accounts for those chemical elements affecting weldability. The ASTM A706/A706M specification and the ANSI/AWS D1.4 Welding Code have the same formula for C.E.:

$$C.E. = \%C + \%Mn/6 + \%Cu/40 + \%Ni/20 + \%Cr/10 - \%Mo/50 - \%V/10$$

The ASTM A706/A706M specification limits C.E. to a maximum of 0.55%.

ASTM specification A615/A615M for billet-steel reinforcing bars includes a statement in its scope concerning welding:

> "...Welding of material in this specification should be approached with caution since no specific provisions have been included to enhance its weldability. When the steel is to be welded, a welding procedure suitable for the chemical composition and intended use or service should be used."

The A615/A615M specification then recommends use of ANSI/AWS D1.4 for welding of reinforcing bars. The C.E. formula in ANSI/AWS D1.4 for billet-steel bars is:

$$C.E. = \%C + \%Mn/6$$

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 1

MATERIAL SPECIFICATIONS FOR REINFORCING BARS

1.6.2 Project Drawings and Project Specifications

The Architect/Engineer should indicate on the project drawings or in the project specifications:

- The welding of reinforcing bars shall conform to the ANSI/AWS D1.4 Welding Code;
- The type and location of welded splices of reinforcing bars;
- Other required welding.

ANSI/AWS D1.4 requires the Contractor to prepare a written welding procedure specification (WPS) for each welded splice conforming to the requirements of the Welding Code. The ASTM A706/A706M specification requires the reinforcing bar Producer to report the chemical composition and carbon equivalent of the steel. For billet-steel reinforcing bars, the ASTM A615/A615M specification requires the Producer to determine the percentages of certain chemical elements including carbon and manganese. Reporting these material properties should be required in the project specifications so that the Contractor will have the carbon equivalent available for the reinforcing bars to be welded.

1.6.3 CRSI Recommendations

1. Minimize manual arc welding in the field, wherever possible. Consider the use of mechanical splices as an alternative to welded splices.

2. Where arc-welded splices are used, the following are required:

   a. Welding should conform to ANSI/AWS D1.4 "Structural Welding Code —Reinforcing Steel"

   b. Mill test analysis of the reinforcing bars for calculating "carbon equivalent" (C.E.)

   c. Adjustment of welding techniques to suit C.E. values and job-site temperatures

   d. The correct strength, grade, and size of low-hydrogen electrodes, kept oven dry

   e. Qualification tests to certify all welders before beginning a construction project and periodically thereafter during long-term projects

   f. Continuous supervision of all welding operations

   g. Radiography or other suitable nondestructive inspection of a percentage of welds (normally about 25 percent of the welds selected at random)

   h. Occasional quality control tests of actual welds removed from the structure when nondestructive test results are unsatisfactory

3. Chemical analyses are not ordinarily meaningful for rail-steel and axle-steel reinforcing bars. Welding of these types of bars is not recommended.

4. Unless approved by the Architect/Engineer, never permit field welding of crossing bars for assembly and fastening of reinforcement. Such welds, called "tack" welding or "spot" welding, may affect the strength and ductility of the bars. Reinforcement should be assembled and fastened with tie wire to avoid harming the bars.

1.7. Identification Marks*—ASTM Standard Reinforcing Bars

The ASTM specifications for reinforcing bars require identification marks to be rolled into the surface on one side of the bar to denote the Producer's mill designation, bar size, type of steel, and minimum yield designation. Grade 60 [420] bars show these marks in the following order:

lst—Producing Mill (usually a letter)
2nd—Bar Size Number (#3 through #11, #14, #18 [#10 through #57])
3rd—Type of Steel:


for Billet-Steel (A615/A615M)


for Low-Alloy Steel (A706/A706M)


for Rail-Steel (A996/A996M)


for Rail-Steel (A996/A996M)


for Axle-Steel (A996/A996M)

4th—Minimum Yield Strength Designation

A mark for minimum yield designation or grade is required for Grade 60 [420] and Grade 75 [520] bars only. Grade 60 [420] bars can either have one single longitudinal line (a grade line) or the number 60 [4] (a grade mark). Grade 75 [520] bars can either have two grade lines or the grade mark 75 [5].

A grade line is smaller and is located between the two main longitudinal ribs which are on opposite sides of all bars rolled in the United States. A grade line must be continued through at least 5 deformation spaces, and it may be placed on the same side of the bar as the other markings or on the opposite side.

Grade 40 [300] and 50 [350] bars are required to have only the first three identification marks. No grade mark or grade line for minimum yield strength is required.

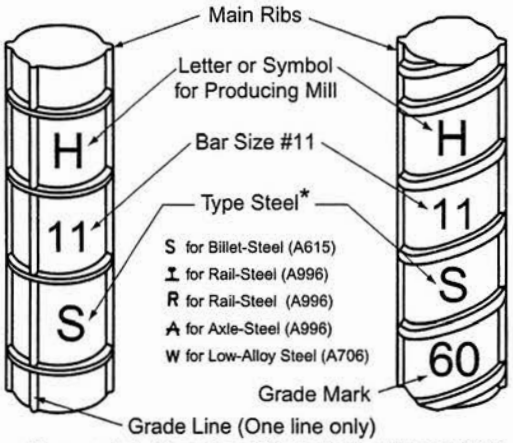
VARIATIONS: Bar identification marks may also be oriented to read horizontally (at 90° to those illustrated). Grade mark numbers may be placed within separate consecutive deformation spaces to read vertically or horizontally.

*See Appendix A for complete identification marks of Grade 60 [420] reinforcing bars produced by all U.S. Producers. The marks, listed alphabetically by producing mill, include the identification requirements of ASTM and the deformation pattern used by each mill.

Documents
Document Sharing Hub

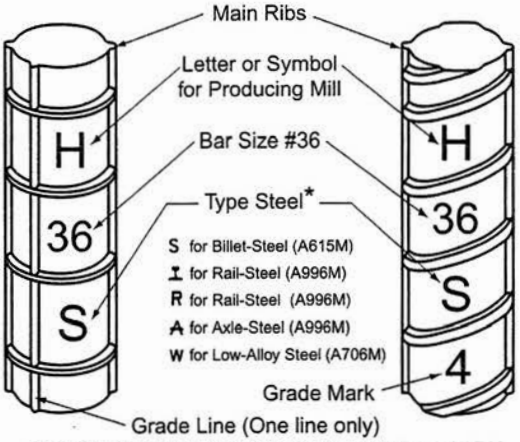
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

MATERIAL SPECIFICATIONS FOR REINFORCING BARS



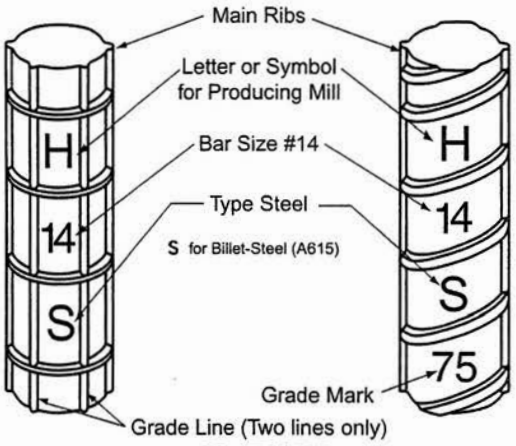
*Bars marked with an S and W meet both A615 and A706

GRADE 60

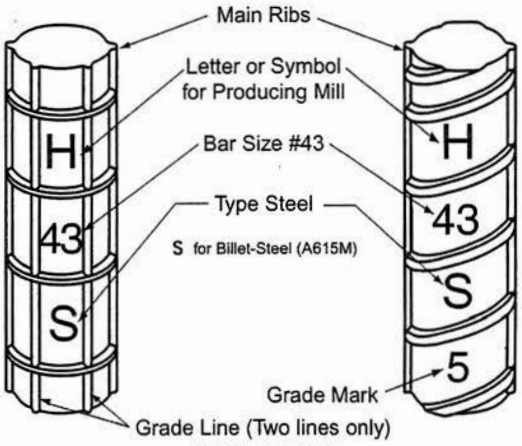


*Bars marked with an S and W meet both A615 and A706

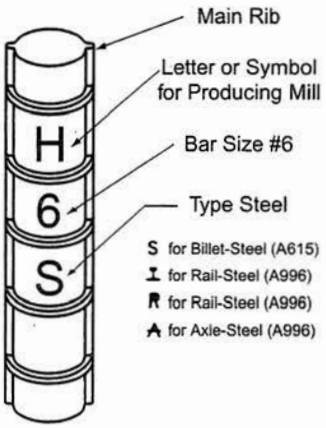
GRADE 420



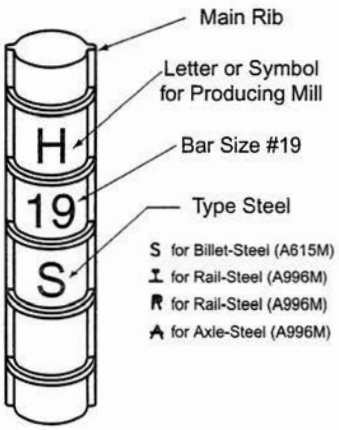
GRADE 75



GRADE 520



GRADES 40 AND 50



GRADES 300 AND 350

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 2

WELDED WIRE FABRIC (WWF)

2.1. Introduction

This chapter presents information for specifying and estimating welded wire fabric (WWF) used in building construction. Discussion of epoxy-coated WWF, and handling, shipping, unloading and placing of WWF are also included.

2.2. ASTM Specifications

Welded wire fabric consists of wires arranged in a square or rectangular configuration. The wires are welded at their intersections. WWF must conform to ASTM A185 if made of plain wire or to ASTM A497 if made of deformed wire or a combination of deformed and plain wire. These specifications require tensile, reduction of area and bend tests on the fabric, and shear tests on the welded intersections. A minimum yield strength of 65,000 psi [450 MPa] is required for plain WWF (A185) and a minimum of 70,000 psi [485 MPa] for deformed WWF (A497). ASTM A82 (plain wire) and A496 (deformed wire) are companion specifications that prescribe the requirements for the wire used for manufacturing welded wire fabric.

Unless otherwise specified by the Architect/Engineer, welded wire fabric conforming to ASTM A185 will be furnished.

Welded wire fabric can be produced with high-strength wires of minimum yield strengths to 80,000 psi [550 MPa]. Higher minimum yield strengths allow the use of less material in certain applications.

Welded wire fabric can be fabricated to make beam stirrups and column ties.

2.3. Style Identification

Plain wire is denoted by the letter "W" ["MW"] and deformed wire by the letter "D" ["MD"]. The letter is followed by a number indicating cross-sectional area in hundredths of a square inch [square millimeters].

Welded wire fabric is usually shown on project drawings with the abbreviation WWF followed by spacings of longitudinal wires and then transverse wires and last by the sizes of longitudinal and transverse wires.

An example style designation (see Figure 2-1) is: WWF 6 × 12—W16 × W8 [152 × 305 – MW103 × MW52]. This designation identifies a style of plain welded wire fabric in which:

Spacing of longitudinal wires	= 6 in.	[152 mm]
Spacing of transverse wires	= 12 in.	[305 mm]
Longitudinal wire size	= W16	[MW103]
Transverse wire size	= W8	[MW52]

A deformed WWF style would be designated in the same manner with the appropriate D [MD] number wire spacings and sizes.

It is important to note that the terms "longitudinal" and "transverse" are related to the method of WWF manufacture and have no reference to the orientation of the wires with respect to the orientation of the reinforced concrete structure.

2.4. Specifying Welded Wire Fabric

The Architect/Engineer's selection of welded wire fabric styles should include production considerations as well as steel area requirements. Maximum economies in production and handling can be achieved by utilizing repetition of styles and duplication of sheet and/or roll dimensions to the fullest extent possible.

Welded wire fabric is manufactured in the form of sheets and rolls. Rolls are generally stocked in W1.4 to W4 [MW9 to MW26] wire sizes only. Roll widths vary from 5 to 8 feet [1.5 to 2.4 m]. Lengths vary with application and convenience of handling and shipping. Rolls should be straightened. Standard widths of sheets vary between 7 to 10 feet [2.1 to 3.1 m] for building construction and up to 13 feet [4 m] for pavement.

The maximum sheet size (width and/or length) may be limited by shipping restrictions as well as manufacturing limitations.

Development lengths and lap splice lengths for welded wire fabric must be specified by the Architect /Engineer in accordance with the ACI 318 Building Code. Lap splice lengths are usually a minimum of one wire space plus 2 in. [50 mm] for plain wire and 8 in. [200 mm] for deformed wire.

Certain styles of welded wire fabric as shown in Table 2-1 have been recommended by the Wire Reinforcement Institute as common styles. Manufacturers of WWF can meet specific steel area requirements when ordered for designated projects, or in some localities, may be available from inventory.

2.5. Detailing Welded Wire Fabric

The quantity of welded wire fabric detailed and supplied should include the net area shown on the project drawings or required in the project specifications plus sufficient material to include lap splices.

2.5.1 Width

Width is defined as the center-to-center distance between the outside longitudinal wires. Overall width is defined as the width plus side overhangs.

AVA Documents Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

The side overhangs of transverse wires should be no greater than one inch [25 mm] unless otherwise specified by the Architect/Engineer. Transverse wires may be specified to have a specific overhang or no overhang (flush sides).

2.5.2 Length

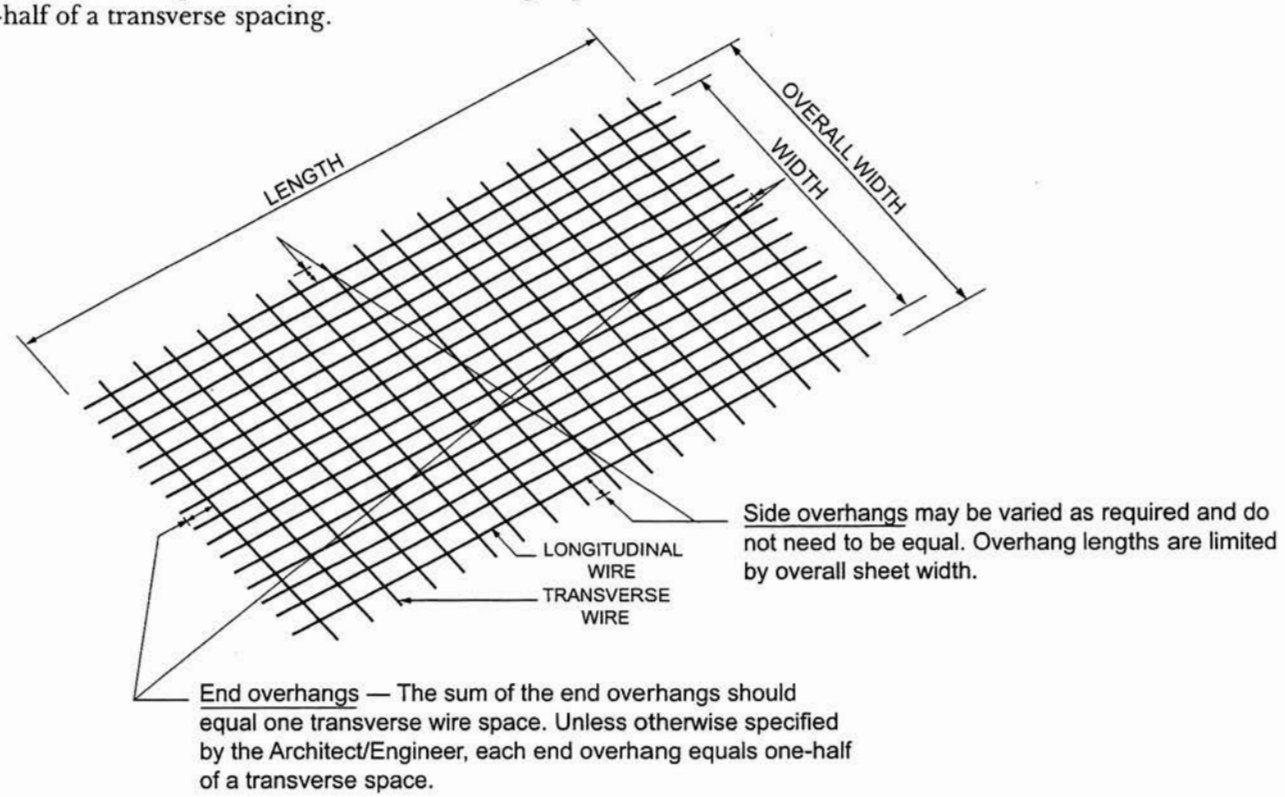
Welded wire fabric in roll form can be manufactured in various lengths, up to the maximum weight per roll convenient for handling. The lengths of rolls vary with the individual manufacturing practices of producers. Typical lengths are 100, 150 and 200 feet [31, 46 and 61 m]. Sheet or roll length is defined as the length, tip to tip, of longitudinal wires. This length should be a whole multiple of the transverse wire spacing.

The sum of the two end overhangs on either sheets or rolls should be equal to one transverse wire spacing. Unless otherwise specified, each end overhang equals one-half of a transverse spacing.

2.6. ASTM Specification for Epoxy-Coated Wire and Welded Wire Fabric

Epoxy-coated wire and welded wire fabric are used in reinforced concrete construction as a corrosion-protection system.

The ASTM specification A884/A884M covers the epoxy coating of plain and deformed steel wire, and plain and deformed steel welded wire fabric. The specification includes requirements for the epoxy-coating material; surface preparation of the steel prior to application of the coating; the method of application of the coating; limits on coating thickness; and acceptance tests to ensure that the coating was properly applied. All damaged areas of coating on the wires, which occur during manufacture and handling to the point of shipment to the job-site, have to be repaired (touched-up) with patching material.



Industry Method of Designating Style:
Example: WWF 6 x 12 — W16 x W8 [152 x 305 — MW103 x MW52]

Longitudinal wire spacing . . . . . 6 in. [152 mm]	Longitudinal wire size . . . . W16 [MW103]
Transverse wire spacing . . . . 12 in. [305 mm]	Transverse wire size . . . . . W8 [MW52]

FIGURE 2-1 STYLE IDENTIFICATION OF WELDED WIRE FABRIC

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

WELDED WIRE FABRIC (WWF)

TABLE 2-1 COMMON STYLES OF WELDED WIRE FABRIC SHEETS

Inch-Pound Units			Metric Units		
Style	Area ($in.^2/ft$)	Weight* ($lb/100\ ft^2$)	Style	Area (mm^2/m)	Mass* (kg/m^2)
4 x 4 – W1.4 x W1.4**	0.042	31	102 x 102 – MW9 x MW9**	88.9	1.51
4 x 4 – W2.0 x W2.0**	0.060	44	102 x 102 – MW13 x MW13**	127.0	2.15
4 x 4 – W2.9 x W2.9**	0.087	62	102 x 102 – MW19 x MW19**	184.2	3.03
4 x 4 – W3.1 x W3.1	0.093	65	102 x 102 – MW20 x MW20	196.9	3.17
4 x 4 – W4.0 x W4.0**	0.120	88	102 x 102 – MW26 x MW26**	254.0	4.30
6 x 6 – W1.4 x W1.4**	0.028	21	152 x 152 – MW9 x MW9 **	59.3	1.03
6 x 6 – W2.0 x W2.0**	0.040	30	152 x 152 – MW13 x MW13**	84.7	1.46
6 x 6 – W2.9 x W2.9**	0.058	42	152 x 152 – MW19 x MW19**	122.8	2.05
6 x 6 – W4.0 x W4.0**	0.080	58	152 x 152 – MW26 x MW26 **	169.4	2.83
6 x 6 – W4.2 x W4.2	0.084	60	152 x 152 – MW27 x MW27	177.8	3.08
6 x 6 – W4.4 x W4.4	0.088	63	152 x 152 – MW28 x MW28	186.3	3.22
6 x 6 – W4.7 x W4.7	0.094	68	152 x 152 – MW30 x MW30	199.0	3.32
6 x 6 – W7.5 x W7.5	0.150	108	152 x 152 – MW48 x MW48	317.5	5.52
6 x 6 – W8.1 x W8.1	0.162	116	152 x 152 – MW52 x MW52	342.9	5.66
6 x 6 – W8.3 x W8.3	0.166	119	152 x 152 – MW54 x MW54	351.4	5.81
12 x 12 – W8.3 x W8.3	0.083	63	305 x 305 – MW54 x MW54	175.7	3.08
12 x 12 – W8.8 x W8.8	0.088	66	305 x 305 – MW57 x MW57	186.3	3.22
12 x 12 – W9.1 x W9.1	0.091	69	305 x 305 – MW59 x MW59	192.6	8.25
12 x 12 – W9.4 x W9.4	0.094	71	305 x 305 – MW61 x MW61	199.0	3.47
12 x 12 – W15 x W15	0.150	113	305 x 305 – MW97 x MW97	317.5	5.52
12 x 12 – W16 x W16	0.160	120	305 x 305 – MW103 x MW103	338.7	5.61
12 x 12 – W16.6 x W16.6	0.166	125	305 x 305 – MW107 x MW107	351.4	9.72
12 x 12 – W17.1 x W17.1	0.171	128	305 x 305 – MW110 x MW110	362.0	6.25

* Weight [mass] based on 60-in. [1524-mm] wide sheets (c.-c.) with 1-in. [25-mm] side overhang and standard end overhang.

** These styles may be obtained in roll form. It is recommended that rolls be straightened and cut to size before placement.

Example Calculations:

6 x 6 – W4.0 x W4.0
Long. Wires (Table 2-2(a)) = 29.92
Tran. Wires (Table 2-2(c)) = 28.11
Total = 58.03 = 58 $lb/100\ ft^2$

152 x 152 – MW52 x MW52
Long. Wires (Table 2-2(b)) = 2.92
Tran. Wires (Table 2-2(d)) = 2.74
Total = 5.66 kg/m^2

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

WELDED WIRE FABRIC (WWF)

TABLE 2-2(a) UNIT WEIGHT OF LONGITUDINAL WIRES FOR WELDED WIRE FABRIC (INCH-POUND)

Wire Size, W or D	Nom. Diam. (in.)	Weight (lb/100 ft²)* of Longitudinal Wires Per Spacing (in.)								
		2	3	4	5	6	8	9	10	12
45	0.757	948.60	642.60	489.60	397.80	336.60	260.10	234.40	214.20	183.60
31	0.628	653.40	442.68	337.28	274.04	231.88	179.18	161.68	147.56	126.48
30	0.618	632.40	428.40	326.40	265.20	224.40	173.40	156.46	142.80	122.40
28	0.597	590.24	399.84	304.64	247.52	209.44	161.84	146.03	133.28	114.24
26	0.575	548.08	371.28	282.88	229.84	194.48	150.28	135.60	123.76	106.08
24	0.553	505.92	342.72	261.12	212.16	179.52	138.72	125.17	114.24	97.92
22	0.529	463.76	314.16	239.36	194.48	164.56	127.16	114.74	104.72	89.76
20	0.505	421.60	285.60	217.60	176.80	149.60	115.60	104.31	95.20	81.60
18	0.479	379.44	257.04	195.84	159.12	134.64	104.04	93.88	85.68	73.44
16	0.451	337.28	228.48	174.48	141.44	119.68	92.48	83.45	76.16	65.28
14	0.422	295.12	199.92	152.32	123.76	104.72	80.92	73.01	66.64	57.12
12	0.391	252.96	171.36	130.56	106.08	89.76	69.36	62.58	57.12	48.96
11	0.374	231.88	157.08	119.68	97.24	82.28	63.58	57.37	52.36	44.88
10.5	0.366	221.34	149.94	114.24	92.82	78.54	60.69	54.76	49.98	42.84
10	0.357	210.80	142.80	108.80	88.40	74.80	57.80	52.15	47.60	40.80
9.5	0.348	200.26	135.66	103.36	83.98	71.06	54.91	49.55	45.22	38.76
9	0.339	189.72	128.52	97.92	79.56	67.32	52.02	46.94	42.84	36.72
8.5	0.329	179.18	121.38	92.48	75.14	63.58	49.13	44.33	40.46	34.68
8	0.319	168.64	114.24	87.04	70.72	59.84	46.24	41.73	38.08	32.64
7.5	0.309	158.10	107.10	81.60	66.30	56.10	43.35	39.11	35.70	30.60
7	0.299	147.56	99.96	76.16	61.88	52.36	40.46	36.51	33.32	28.56
6.5	0.288	137.02	92.82	70.72	57.46	48.62	37.57	33.90	30.94	26.52
6	0.276	126.48	85.68	65.28	53.04	44.88	34.68	31.29	28.56	24.48
5.5	0.265	115.94	78.54	69.84	48.62	41.14	31.79	28.69	26.18	22.44
5	0.252	105.40	71.40	54.40	44.20	37.40	28.90	36.08	23.80	20.40
4.5	0.239	94.86	64.26	48.96	39.78	33.66	26.01	23.47	21.42	18.36
4	0.226	84.32	57.12	43.52	35.36	29.92	23.12	20.87	19.04	16.32
3.5	0.211	73.78	49.98	38.08	30.94	26.18	20.23	18.26	16.66	14.28
3	0.195	63.24	42.84	32.64	26.52	22.44	17.34	15.65	14.28	12.24
2.9	0.192	61.13	41.41	31.55	25.64	21.69	16.76	15.11	13.80	11.83
2.5	0.178	52.70	35.70	27.20	22.10	18.70	14.45	13.04	11.90	10.20
2	0.160	42.16	28.56	21.76	17.68	14.96	11.56	10.44	9.52	8.16
1.4	0.134	29.51	19.99	15.23	12.38	10.47	8.09	7.29	6.66	5.71

*Weight based on standard end overhang.

Note: This table should be used for estimating purposes only. Actual weights of welded wire fabric will vary from those shown above, depending upon the width of rolls or sheets and lengths of overhangs. No allowance is made in this table for the extra weight of fabric required for lap splices.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

WELDED WIRE FABRIC (WWF)

TABLE 2-2(b) UNIT MASS OF LONGITUDINAL WIRES FOR WELDED WIRE FABRIC (METRIC)

Wire Size, MW or MD	Nom. Diam. (mm)	Mass (kg/m²)* of Longitudinal Wires Per Spacing (mm)								
		51	76	102	127	152	203	229	254	305
290	19.23	46.31	31.37	23.90	19.42	16.43	12.71	11.44	10.46	8.96
200	15.96	31.94	21.59	16.45	13.37	11.31	8.74	7.89	7.20	6.17
194	15.70	30.84	20.89	15.92	12.93	10.94	8.36	7.63	6.96	5.97
181	15.17	28.79	19.50	14.86	12.07	10.22	7.89	7.12	6.50	5.57
168	14.61	26.73	18.11	13.80	11.21	9.49	7.33	6.61	6.04	5.17
155	14.04	24.68	16.72	12.74	10.35	8.76	6.77	6.15	5.57	4.78
142	13.44	23.60	15.32	11.67	9.49	8.03	6.20	5.60	5.11	4.38
129	12.82	20.56	13.94	10.61	8.62	7.30	5.84	5.09	4.64	3.98
116	12.16	18.51	12.54	9.55	7.76	6.57	5.07	4.58	4.23	3.58
103	11.46	16.45	11.14	8.49	6.90	5.84	4.51	4.07	3.71	3.18
90	10.72	14.39	9.75	7.43	6.04	5.11	3.95	3.55	3.25	2.79
77	9.93	12.34	8.38	6.37	6.17	4.38	3.38	3.05	2.79	2.39
71	9.51	11.31	7.66	5.81	4.74	4.01	3.10	2.80	2.55	2.19
68	9.29	10.80	7.31	5.57	4.53	3.83	2.96	2.67	2.44	2.09
65	9.06	10.27	6.96	5.31	4.31	3.65	2.82	2.54	2.32	1.99
61	8.83	9.77	6.62	5.04	4.10	3.47	2.68	2.42	2.21	1.89
58	8.60	9.25	6.27	4.78	3.88	3.28	2.54	2.29	2.09	1.79
55	8.36	8.74	5.82	4.56	3.66	3.10	2.40	2.16	1.97	1.69
52	8.11	8.23	5.57	4.25	3.45	2.92	2.26	2.04	1.86	1.59
48	7.85	7.71	5.22	3.98	3.23	2.74	2.11	1.91	1.74	1.49
45	7.58	7.20	4.88	3.71	3.02	2.55	1.97	1.78	1.63	1.39
42	7.31	6.68	4.53	3.45	2.80	2.37	1.83	1.65	1.51	1.29
39	7.02	6.17	4.18	3.18	2.59	2.19	1.69	1.53	1.39	1.19
35	6.72	5.65	3.83	2.92	2.37	2.01	1.55	1.40	1.28	1.09
32	6.41	5.14	3.48	2.65	2.18	1.82	1.41	1.27	1.18	0.99
29	6.08	4.63	3.13	2.39	1.94	1.64	1.27	1.14	1.04	0.90
26	5.73	4.11	2.79	2.12	1.72	1.46	1.13	1.02	0.93	0.80
23	5.36	3.60	2.44	1.86	1.51	1.28	0.99	0.89	0.81	0.70
19.4	4.96	4.06	2.09	1.59	1.29	1.09	0.85	0.76	0.70	0.60
18.7	4.88	2.98	2.02	1.54	1.25	1.06	0.82	0.74	0.67	0.58
16	4.53	2.57	1.74	1.33	1.08	0.91	0.70	0.64	0.58	0.50
13	4.05	2.06	1.39	1.03	0.87	0.73	0.56	0.51	0.46	0.40
9	3.39	1.44	0.98	0.74	0.60	0.51	0.40	0.36	0.33	0.28

*Mass based on standard end overhang.

Note: This table should be used for estimating purposes only. Actual mass of welded wire fabric will vary from those shown above, depending upon the width of rolls or sheets and lengths of overhangs. No allowance is made in this table for the extra mass of fabric required for lap splices.

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

TABLE 2-2(c) UNIT WEIGHT OF TRANSVERSE WIRES FOR WELDED WIRE FABRIC (INCH-POUND)

Wire Size, W or D	Nom. Diam. (in.)	Weight (lb/100 ft²)* of Transverse Wires Per Spacing (in.)								
		2	3	4	5	6	8	9	10	12
45	0.757	948.57	632.38	474.29	379.43	316.19	237.14	210.79	189.72	158.10
31	0.628	653.48	435.65	326.74	261.39	217.83	163.37	145.22	130.70	108.91
30	0.618	632.40	421.40	316.20	252.96	210.80	158.10	140.53	126.48	105.40
28	0.597	590.24	393.49	295.12	236.10	196.75	147.56	131.17	118.05	98.37
26	0.575	548.08	365.38	274.04	219.23	182.70	137.02	121.80	109.62	91.34
24	0.553	505.92	337.28	252.96	202.37	168.64	126.48	112.43	101.18	84.32
22	0.529	463.76	309.17	231.88	185.50	154.59	115.94	103.06	92.75	77.29
20	0.505	421.60	281.06	210.80	168.64	140.53	105.40	93.69	84.32	70.26
18	0.479	379.44	252.96	189.72	151.78	126.48	94.86	84.32	75.89	63.24
16	0.451	337.28	224.85	168.64	134.91	112.43	84.32	74.95	67.46	56.21
14	0.422	295.12	196.76	147.56	118.05	98.37	73.78	65.58	59.02	49.19
12	0.391	252.96	168.64	126.48	101.18	84.32	63.24	56.21	50.59	42.16
11	0.374	231.88	154.59	115.94	92.75	77.29	57.97	51.53	46.38	38.65
10.5	0.366	221.34	147.56	110.67	88.54	73.78	55.34	49.19	44.27	36.89
10	0.357	210.80	140.53	105.40	84.32	70.27	52.70	46.84	42.16	35.13
9.5	0.348	200.28	133.51	100.13	80.11	66.76	50.07	44.50	40.05	33.38
9	0.339	189.72	126.48	94.86	75.89	63.24	47.43	42.16	37.94	31.62
8.5	0.329	179.18	119.45	89.59	71.67	59.73	44.80	39.82	35.84	29.86
8	0.319	168.64	112.43	84.32	67.46	56.21	42.16	37.48	33.73	28.11
7.5	0.309	158.10	105.40	79.05	63.24	52.70	39.53	35.14	31.62	26.35
7	0.299	147.56	98.37	73.78	59.02	49.19	36.89	32.79	29.51	24.59
6.5	0.288	137.02	91.35	68.51	54.81	45.68	34.26	30.45	27.41	22.84
6	0.276	126.48	84.32	63.24	50.59	42.16	31.62	28.11	25.30	21.08
5.5	0.265	115.94	77.30	57.97	46.38	38.65	28.99	25.77	23.19	19.33
5	0.252	105.40	70.27	52.70	42.16	35.13	26.35	23.42	21.08	17.57
4.5	0.239	94.86	63.24	47.43	37.95	31.62	23.72	21.08	18.97	15.81
4	0.226	84.32	56.21	42.16	33.73	28.11	21.08	18.74	16.86	14.05
3.5	0.211	73.78	49.19	36.89	29.51	24.60	18.45	16.40	14.76	12.30
3	0.195	63.24	42.16	31.62	25.30	21.08	15.81	14.05	12.65	10.54
2.9	0.192	61.13	40.75	30.56	24.45	20.38	15.28	13.58	12.23	10.19
2.5	0.178	52.70	35.13	26.35	21.08	17.57	13.18	11.71	10.54	8.78
2	0.160	42.16	28.11	21.08	16.86	14.05	10.54	9.37	8.43	7.03
1.4	0.134	29.51	19.67	14.76	11.80	9.84	7.38	6.56	5.90	4.92

* Weight based on 60-in. wide sheets (c.-c.) with 1-in. side overhang.

Note: This table should be used for estimating purposes only. Actual weights of welded wire fabric will vary from those shown above, depending upon the width of rolls or sheets and lengths of overhangs. No allowance is made in this table for the extra weight of fabric required for lap splices.

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

WELDED WIRE FABRIC (WWF)

TABLE 2-2(d) UNIT MASS OF TRANSVERSE WIRES FOR WELDED WIRE FABRIC (METRIC)

Wire Size, MW or MD	Nom. Diam. (mm)	Mass (kg/m²)* of Transverse Wires Per Spacing (mm)								
		51	76	102	127	152	203	229	254	305
290	19.23	45.72	30.48	22.86	17.91	15.24	11.43	9.91	9.14	7.62
200	15.96	32.36	21.25	15.94	12.75	10.62	7.97	7.08	6.37	5.31
194	15.70	30.84	20.56	15.52	12.34	10.28	7.71	6.85	6.17	5.14
181	15.17	28.79	19.19	14.44	11.52	9.60	7.20	6.40	5.76	4.80
168	14.61	26.73	17.82	13.37	10.69	8.91	6.68	5.94	5.35	4.46
155	14.04	24.88	16.45	12.34	9.87	8.23	6.17	5.48	4.93	4.11
142	13.44	22.62	15.08	11.31	9.06	7.54	5.65	5.03	4.52	3.77
129	12.82	20.66	13.71	10.28	8.23	6.85	5.14	4.57	4.11	3.43
116	12.16	18.51	12.34	9.25	7.40	6.17	4.63	4.11	3.70	3.08
103	11.46	16.45	10.97	8.23	6.58	5.48	4.11	3.66	3.29	2.74
90	10.72	14.39	9.60	7.20	5.76	4.80	3.60	3.20	2.88	2.40
77	9.93	12.34	8.23	6.17	4.93	4.11	3.08	2.74	2.47	2.08
71	9.51	11.31	7.54	5.65	4.52	3.77	2.83	2.52	2.26	1.89
68	9.29	10.80	7.20	5.40	4.32	3.60	2.70	2.40	2.16	1.80
65	9.06	10.28	6.85	5.14	4.11	3.43	2.57	2.28	2.06	1.71
61	8.83	9.77	6.51	4.88	3.91	3.26	2.44	2.17	1.95	1.63
58	8.60	9.25	6.17	4.63	3.70	3.08	2.31	2.06	1.85	1.54
55	8.36	8.74	5.83	4.37	3.50	2.91	2.19	1.94	1.75	1.46
52	8.11	8.24	5.48	4.11	3.29	2.74	2.06	1.83	1.65	1.37
48	7.85	7.71	5.14	3.86	3.08	2.57	1.93	1.71	1.55	1.29
45	7.58	7.20	4.80	3.60	2.88	2.40	1.80	1.60	1.44	1.20
42	7.31	6.68	4.45	3.34	2.67	2.23	1.67	1.49	1.34	1.11
39	7.02	6.17	4.11	3.08	2.47	2.00	1.54	1.37	1.23	1.03
35	6.72	5.65	3.77	2.83	2.26	1.89	1.41	1.26	1.13	0.94
32	6.41	5.14	3.43	2.57	2.06	1.71	1.29	1.14	1.03	0.86
29	6.08	4.63	3.08	2.31	1.85	1.54	1.16	1.03	0.93	0.77
26	5.73	4.11	2.74	2.06	1.65	1.27	1.03	0.91	0.82	0.69
23	5.36	3.60	2.40	1.80	1.44	1.20	0.90	0.80	0.72	0.60
19.4	4.96	3.08	2.08	1.54	1.23	1.03	0.77	0.69	0.62	0.51
18.7	4.88	2.95	1.96	1.47	1.15	0.98	0.74	0.64	0.59	0.49
16	4.53	2.57	1.76	1.29	1.03	0.86	0.64	0.57	0.51	0.43
13	4.05	2.06	1.37	1.03	0.81	0.69	0.51	0.46	0.41	0.34
9	3.39	1.42	0.95	0.71	0.56	0.47	0.36	0.31	0.28	0.24

* Mass based on 1524-mm wide sheets (c.-c.) with 25-mm side overhang.

Note: This table should be used for estimating purposes only. Actual mass of welded wire fabric will vary from those shown above, depending upon the width of rolls or sheets and lengths of overhangs. No allowance is made in this table for the extra mass of fabric required for lap splices.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

WELDED WIRE FABRIC (WWF)

TABLE 2-3(a) CROSS-SECTIONAL AREA AND WEIGHT OF WELDED WIRE FABRIC (INCH-POUND)

Wire Size, W or D	Nom. Diam. (in.)	Nom. Weight (lb/ft)	Area of Steel (in.²/ft) Per Wire Spacing (in.)						
			2	3	4	6	8	10	12
45	0.757	1.530	2.700	1.800	1.350	0.900	0.675	0.540	0.450
31	0.628	1.054	1.860	1.240	0.930	0.620	0.465	0.372	0.310
30	0.618	1.020	1.800	1.200	0.900	0.600	0.450	0.360	0.300
28	0.597	0.952	1.680	1.120	0.840	0.560	0.420	0.336	0.280
26	0.575	0.884	1.560	1.040	0.780	0.520	0.390	0.312	0.260
24	0.553	0.816	1.440	0.960	0.720	0.480	0.360	0.288	0.240
22	0.529	0.748	1.320	0.880	0.660	0.440	0.330	0.264	0.220
20	0.505	0.680	1.200	0.800	0.600	0.400	0.300	0.240	0.200
18	0.479	0.612	1.080	0.720	0.540	0.360	0.270	0.216	0.180
16	0.451	0.544	0.960	0.640	0.480	0.320	0.240	0.192	0.160
14	0.422	0.476	0.840	0.560	0.420	0.280	0.210	0.168	0.140
12	0.391	0.408	0.720	0.480	0.360	0.240	0.180	0.144	0.120
11	0.374	0.374	0.660	0.440	0.330	0.220	0.165	0.132	0.110
10.5	0.366	0.357	0.630	0.420	0.315	0.210	0.158	0.126	0.105
10	0.357	0.340	0.600	0.400	0.300	0.200	0.150	0.120	0.100
9.5	0.348	0.323	0.570	0.380	0.285	0.190	0.143	0.114	0.095
9	0.339	0.306	0.540	0.360	0.270	0.180	0.135	0.108	0.090
8.5	0.329	0.289	0.510	0.340	0.255	0.170	0.128	0.102	0.085
8	0.319	0.272	0.480	0.320	0.240	0.160	0.120	0.096	0.080
7.5	0.309	0.255	0.450	0.300	0.225	0.150	0.113	0.090	0.075
7	0.299	0.238	0.420	0.280	0.210	0.140	0.105	0.084	0.070
6.5	0.288	0.221	0.390	0.260	0.195	0.130	0.098	0.078	0.065
6	0.276	0.204	0.360	0.240	0.180	0.120	0.090	0.072	0.060
5.5	0.265	0.187	0.330	0.220	0.165	0.110	0.083	0.066	0.055
5	0.252	0.170	0.300	0.200	0.150	0.100	0.075	0.060	0.050
4.5	0.239	0.153	0.270	0.180	0.135	0.090	0.068	0.054	0.045
4	0.226	0.136	0.240	0.160	0.120	0.080	0.060	0.048	0.040
3.5	0.211	0.119	0.210	0.140	0.105	0.070	0.053	0.042	0.035
3	0.195	0.102	0.180	0.120	0.090	0.060	0.045	0.036	0.030
2.9	0.192	0.099	0.174	0.116	0.087	0.058	0.044	0.035	0.029
2.5	0.178	0.085	0.150	0.100	0.075	0.050	0.038	0.030	0.025
2	0.160	0.068	0.120	0.080	0.060	0.040	0.030	0.024	0.020
1.4	0.134	0.048	0.084	0.056	0.042	0.028	0.021	0.017	0.014

Notes:

1. The above listing of plain and deformed wire sizes represents wires normally selected to manufacture welded wire fabric to specific areas of reinforcement. Wire sizes other than those listed above, including larger sizes, may be available if the quantity required is sufficient to justify manufacture.
2. 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.
3. The ACI Building Code requirements for tension development lengths and tension lap splice lengths of welded wire fabric are not included in this chapter. These design requirements are covered in *Reinforcement Anchorages and Splices* available from CRSI. For additional information, see *Manual of Standard Practice—Structural Welded Wire Fabric* and *Structural Detailing Manual*, both published by the Wire Reinforcement Institute.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

WELDED WIRE FABRIC (WWF)

TABLE 2-3(b) CROSS-SECTIONAL AREA AND MASS OF WELDED WIRE FABRIC (METRIC)

Wire Size, MW or MD	Nom. Diam. (mm)	Nom. Mass (kg/m)	Area of Steel (mm^2/m) Per Wire Spacing (mm)						
			51	76	102	152	203	254	305
290	19.23	2.277	5715	3810	2858	1905	1429	1143	953
200	15.96	1.569	3937	2625	1969	1312	984	787	656
194	15.70	1.518	3810	2540	1905	1270	952	762	635
181	15.17	1.417	3556	2371	1778	1185	889	711	593
168	14.61	1.316	3302	2201	1651	1101	826	660	550
155	14.04	1.214	3048	2032	1524	1016	762	610	508
142	13.44	1.113	2794	1863	1397	931	698	559	466
129	12.82	1.012	2540	1693	1270	847	635	508	423
116	12.16	0.911	2286	1524	1143	762	571	457	381
103	11.46	0.810	2032	1355	1016	677	508	406	339
90	10.72	0.708	1778	1185	889	593	445	356	296
77	9.93	0.607	1524	1016	762	508	381	305	254
71	9.51	0.557	1397	931	698	466	349	279	233
68	9.29	0.531	1333	889	667	444	333	267	222
65	9.06	0.506	1270	847	635	423	317	254	212
61	8.83	0.481	1206	804	603	402	302	241	201
58	8.60	0.455	1143	762	571	381	286	229	190
55	8.36	0.430	1080	720	540	360	270	216	180
52	8.11	0.405	1016	677	508	339	254	203	169
48	7.85	0.379	952	635	476	317	238	190	159
45	7.58	0.354	889	593	445	296	222	178	148
42	7.31	0.329	826	550	413	275	206	165	138
39	7.02	0.304	762	508	381	254	190	152	127
35	6.72	0.278	698	466	349	233	175	140	116
32	6.41	0.253	635	423	317	212	159	127	106
29	6.08	0.228	571	381	286	190	143	114	95
26	5.73	0.202	508	339	254	169	127	102	85
23	5.36	0.177	445	296	222	148	111	89	74
19.4	4.96	0.152	381	254	190	127	95	76	63
18.7	4.88	0.147	368	246	184	123	92	74	61
16	4.53	0.126	317	212	159	106	79	63	53
13	4.05	0.101	254	169	127	85	63	51	42
9	3.39	0.071	178	119	89	59	44	36	30

Notes:

1. The above listing of plain and deformed wire sizes represents wires normally selected to manufacture welded wire fabric to specific areas of reinforcement. Wire sizes other than those listed above, including larger sizes, may be available if the quantity required is sufficient to justify manufacture.
2. The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same mass per foot as the deformed wire.
3. The ACI Building Code requirements for tension development lengths and tension lap splice lengths of welded wire fabric are not included in this chapter. These design requirements are covered in *Reinforcement Anchorages and Splices* available from CRSI. For additional information, see *Manual of Standard Practice—Structural Welded Wire Fabric* and *Structural Detailing Manual*, both published by the Wire Reinforcement Institute.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

WELDED WIRE FABRIC (WWF)

2.7. Handling, Shipping and Unloading Welded Wire Fabric

Welded wire fabric is shipped in two forms—rolls or sheets. If shipped in roll form, several rolls may be bundled together for efficient handling. Individual rolls are securely tied, so uncoiling will not occur when the bundles are cut.

Sheets are bundled in quantities depending on size and weight [mass] of sheets. Generally, bundles of rolls or sheets will weigh between 2,000 and 5,000 pounds [900 to 2300 kg]. Banding is used for shipping stability only. Bundles should never be lifted by the steel banding.

If required by the Buyer, bundles can be assembled by flipping alternate sheets, allowing the sheets to "nest." This arrangement allows for a greater number of sheets to be stacked in a given height and provides some benefit in added stability. Unless required by the Buyer, sheets are not flipped.

At the shipping destination (either job-site or storage facility), the bundles are unloaded with a forklift, or a front end loader equipped with lifting chains, or a crane.

Sheet bundles are usually placed on dunnage spaced every 3 to 4 feet [900 to 1200 mm] for unloading with either a forklift (from beneath the bundle) or a crane (with a sling chain hooked or threaded through the bundle).

At all times during unloading of materials, caution must be exercised and all safety regulations and practices must be observed.

TABLE 2-4 WIRE SIZE CONVERSION *

Inch-Pound Units				Metric Units			
W or D	Area ($in.^2$)	Diam. (in.)	Weight (lb/ft)	MW or MD	Area (mm^2)	Diam. (mm)	Mass (kg/m)
45	0.450	0.757	1.530	290	290	19.23	2.277
31	0.310	0.628	1.054	200	200	15.96	1.569
30	0.300	0.618	1.020	194	194	15.70	1.518
28	0.280	0.597	0.952	181	181	15.17	1.417
26	0.260	0.575	0.884	168	168	14.61	1.316
24	0.240	0.553	0.816	155	155	14.04	1.214
22	0.220	0.529	0.748	142	142	13.44	1.113
20	0.200	0.505	0.680	129	129	12.82	1.012
18	0.180	0.479	0.612	116	116	12.16	0.911
16	0.160	0.451	0.544	103	103	11.46	0.810
14	0.140	0.422	0.476	90	90	10.72	0.708
12	0.120	0.391	0.408	77	77	9.93	0.607
11	0.110	0.374	0.374	71	71	9.51	0.557
10.5	0.105	0.366	0.357	68	68	9.29	0.531
10	0.100	0.357	0.340	65	65	9.06	0.506
9.5	0.095	0.348	0.323	61	61	8.83	0.481
9	0.090	0.339	0.306	58	58	8.60	0.455
8.5	0.085	0.329	0.289	55	55	8.36	0.430
8	0.080	0.319	0.272	52	52	8.11	0.405
7.5	0.075	0.309	0.255	48	48	7.85	0.379
7	0.070	0.299	0.238	45	45	7.58	0.354
6.5	0.065	0.288	0.221	42	42	7.31	0.329
6	0.060	0.276	0.204	39	39	7.02	0.304
5.5	0.055	0.265	0.187	35	35	6.72	0.278
5	0.050	0.252	0.170	32	32	6.41	0.253
4.5	0.045	0.239	0.153	29	29	6.08	0.228
4	0.040	0.226	0.136	26	26	5.73	0.202
3.5	0.035	0.211	0.119	23	23	5.36	0.177
3	0.030	0.195	0.102	19.4	19.4	4.96	0.152
2.9	0.029	0.192	0.099	18.7	18.7	4.88	0.147
2.5	0.025	0.178	0.085	16	16	4.53	0.126
2	0.020	0.160	0.068	13	13	4.05	0.101
1.4	0.014	0.134 1	0.048	9	9	3.39	0.071

* Inch-Pound wire sizes were soft-metricated.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 3

BAR SUPPORTS

3.1. Introduction

Bar supports may be made of steel wire, precast concrete, or plastic.

Most widely used are factory made wire bar supports. Wire bar supports are grouped into four classes according to their intended degree of protection against causing rust spots on the concrete surface. The typical types and sizes of wire bar supports are shown in Table 3-1. Typical wire sizes and geometry are shown in Table 3-2.

The typical types and sizes of precast concrete bar supports and all-plastic bar supports are shown in Tables 3-3 and 3-4, respectively.

In this chapter, industry practices for the various types of wire, precast concrete, and all-plastic bar supports and their placing are presented. These recommendations for usage of bar supports complement those for placing reinforcing bars in Chapter 8.

CRSI neither implies nor expresses approval or certification of any proprietary products. Neither does CRSI establish or promulgate product manufacturing standards. Any products illustrated or described in this chapter are listed for general informational purposes only and are intended only to depict commercially available bar supports presently known to CRSI.

The recommendations in this chapter concerning reinforced concrete construction, and the selection and use of bar supports, should not be substituted for the judgment of an experienced Architect/Engineer as to the best way of achieving specific design requirements in the field.

3.2. Wire Bar Supports

3.2.1 Scope

The industry practices presented in this section are intended to serve as a guide for the selection and utilization of steel wire bar supports used to position reinforcing bars in reinforced concrete.

3.2.2 Typical Types and Sizes

The types and sizes of wire bar supports that are usually available are shown in Table 3-1.

Based on long-term experience and field observations, bar supports made in accordance with the wire sizes and geometrical dimensions shown in Table 3-2 have performed satisfactorily. Bar supports fabricated from larger wire sizes than shown in Table 3-2, but made in accordance with the geometrical dimensions shown in Table 3-2, should also perform satisfactorily and the larger wire sizes should not be cause for rejection.

3.2.3 Rust Prevention

Wire bar supports are classified in terms of methods used to minimize rust spots, or similar blemishes on the surface of the concrete directly caused by the bar supports. The four classes and their intended degree of protection are described in Sections 3.2.5, 3.2.6, 3.2.7 and 3.2.8.

3.2.4 Identification

Project specifications, project drawings, details, and purchase orders generally identify wire bar supports by nominal height, symbol of type of support, and class of protection (Example: 3½-CHC-1 [89-CHC-1] identifies a 3½-in. [89-mm] height, continuous high chair, Class 1-Plastic Protected.)

3.2.5 Class 1—Maximum Protection

PLASTIC-PROTECTED WIRE BAR SUPPORTS—which are intended for use in situations of moderate to severe exposure and/or situations requiring light grinding (1/16 inch [1.6 mm] maximum) or sandblasting of the concrete surface.

Plastic-protected wire bar supports generally are fabricated from cold-drawn steel wire in accordance with the American Steel & Wire (AS&W) wire sizes and the geometrical dimensions shown in Table 3-2. Class 1 bar supports are usually available in Types SB, BB, JC, HC, BC, and CHC, which are furnished with radius bearing legs in the form of a hook or spherical foot at the lower end of the legs. The hook generally consists of elevating the cut end of the support at least ⅛ inch [3 mm] above the supporting base. The spherical foot generally has an outside diameter of not less than 1½ times the specified wire diameter and is not less than ⅛ inch [3 mm] above the supporting base.

Following current industry practice, the plastic protection may be applied either by a dipping operation or by the addition of premolded plastic tips to the legs of the bar support. In both of these methods of protection application, it should be adequately demonstrated that the plastic on the bar support will not chip, crack, deform or peel under ordinary job-site conditions.

Based on experience and field observations of satisfactory performance of Class 1—Plastic-Protected Wire Bar Supports, the plastic should have a thickness of 3/32 inch [2 mm] or greater, at points of contact with the formwork. The plastic should extend upward on the wire to a point at least ½ inch [13 mm] above the formwork.

3.2.6 Class 1A—Maximum Protection (for Use with Epoxy-Coated Reinforcing Bars)

EPOXY-COATED, VINYL-COATED, OR PLASTIC-COATED BRIGHT BASIC WIRE BAR SUPPORTS—which are intended for use in situations of moderate to maximum exposure where no grinding or sandblasting of the concrete surface is required. They are generally used when epoxy-coated reinforcing bars are required.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 3

BAR SUPPORTS

Epoxy-coated, vinyl-coated, or plastic-coated wire bar supports generally are fabricated from cold-drawn carbon steel wire in accordance with the AS&W wire sizes and geometrical dimensions shown in Table 3-2. Class 1A bar supports are usually available in Types SB, BB, HC, JC, BC and CHC, which are furnished with radius bearing legs in the form of a hook at the lower end of the legs. The hook generally consists of elevating the cut end of the leg at least ⅛ inch [3 mm] above the supporting formwork. Also available are Types SBU, BBU and CHCU.

Following current industry recommendations, a minimum 5-mil [125 µm] thickness of coating, or thickness as specified, may be applied by the electrostatic spray method or fluidized bed method.

Prior to application of the coating, the wire should be cleaned to ensure proper adhesion and bond of the dielectric material. After curing, the coating should be free of holes, voids, cracks and deficient areas. Hanger marks are permissible and should not be cause for rejection.

If any of these deficiencies occur during the coating application process, they should be repaired in accordance with the patching material manufacturer's recommendations. It is also common practice in the field to repair small areas of coating that are damaged during shipment.

3.2.7 Class 2—Moderate Protection

STAINLESS STEEL PROTECTED WIRE BAR SUPPORTS—which are intended for use in situations of moderate exposure and/or situations requiring light grinding (1/16 inch [1.6 mm] maximum) or sandblasting of the concrete surface. Class 2 protection may be obtained by use of either Type A or B Stainless Steel Protected Wire Bar Supports. The difference between Type A and Type B supports is the length of the stainless steel tip attached at the bottom of each leg to the bright basic wire.

Caution is advised when using Class 2 bar supports subjected to severe conditions of exposure to sea water, or an atmosphere containing highly corrosive chemicals. Tests indicate, however, that the product should withstand deterioration with equal ability to the concrete surrounding it. Any grinding done to concrete surfaces should be done with an iron free wheel, such as an aluminum oxide wheel, to avoid entrapment of particles that produce rust.

Type A stainless steel protected wire bar supports are usually Types SB, BB, BC, JC, HC and CHC, and are generally fabricated from cold-drawn steel wire in accordance with the AS&W wire sizes and in the typical geometrical dimensions shown in Table 3-2. A tip of stainless steel is attached to the bottom of each leg such that no portion of the non-stainless steel wire lies closer than ¼ inch [6 mm] from the form surface.

Following current industry practice, the legs of the bar support may be fabricated wholly from stainless steel wire without the addition of stainless steel tips.

Type B stainless steel protected wire bar supports are generally fabricated from cold-drawn steel wire so that not any non-stainless steel wire of the bar support lies closer than ¾ inch [19 mm] from the form surface. If required by design, protection exceeding ¾ inch [19 mm] is available by special order.

The stainless steel tip for Type A or Type B stainless steel protected wire bar supports generally is of a size and shape to provide a bearing surface equivalent to the radius bearing described under Class 1 bar supports. Straight-end bearing legs are sometimes furnished for special applications. The stainless steel is generally specified to conform to ASTM Specification A493, AISI Type 430.

Following current industry practice, the legs of the support may be manufactured from stainless steel wire or the legs may be fabricated from cold-drawn carbon steel wire with stainless steel wire leg extensions attached to the bottom of each leg. The wire sizes and the geometrical dimensions generally conform to the requirements of Table 3-2. The leg extensions generally are at least of the same gauge as the wire to which they are welded. The leg extensions are usually so designed that no portion of the carbon steel wire is closer than ¾ inch [19 mm] from the form surface. The legs, or leg extensions, generally provide radius bearing equivalent to that required of Class 1 bar supports. The stainless steel wire is generally specified to conform to ASTM Specification A493, AISI Type 430.

3.2.8 Class 3—No Protection

BRIGHT BASIC WIRE BAR SUPPORTS—which have no protection against rusting and which are intended for use in situations where surface blemishes can be tolerated, or where the bar supports do not come in contact with the exposed concrete surface.

Bright basic wire bar supports are generally fabricated from cold-drawn carbon steel wire in accordance with the AS&W wire sizes and the geometrical dimensions shown in Table 3-2.

Types SB, BB, BC, JC, HC, and CHC are generally furnished with radius bearing legs as described under Class 1 bar supports. Straight-end bearing legs are sometimes furnished for special applications.

Types CHC, SB, BB and HC may be provided with earth-bearing bases (sand plates) of sheet metal having sufficient gauge (thickness) and bearing area. Such supports are designated by the suffice "P"; i.e., CHCP, SBP, BBP, or HCP. Earth-bearing bases are usually confined to Class 3 supports only.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 3

BAR SUPPORTS

Types SB, BB, and CHC may be provided with horizontal runner wires, allowing the bar support to rest on a lower mat of reinforcing bars. Such supports are designated by the suffix "U"; i.e., SBU, BBU, or CHCU. Supports with horizontal runner wires are usually confined to Class 3 supports only.

3.3. Precast Concrete Bar Supports

Precast concrete bar supports are normally supplied in three styles: (1) plain, (2) with wires, and (3) doweled. Plain precast concrete bar supports are used to support reinforcing bars off the ground. Precast concrete bar supports with wires are used in applications such as where it is necessary to maintain position of the support by tying it to the reinforcing bars. Precast concrete bar supports with wires are commonly supplied with two 16-gauge tie wires embedded in the center. Doweled precast concrete bar supports are cast with a hole in the center, approximately 2¼ inches [57 mm] deep, and large enough to insert a #4 [#13] reinforcing bar with a 90° bend at the top. The 90° bend at the top is used to support top bars above the precast concrete bar support. At the same time, the precast concrete bar support can be used to support bottom bars off the ground by placing the bars on either side of the dowel bar. Precast concrete bar supports can also be used to support vertical reinforcement as in a drilled shaft, by placing the supports under the vertical bars of the reinforcing bar cage.

The types and sizes of precast concrete bar supports that are usually available are shown in Table 3-3.

It is recommended that the Supplier review the project specifications for the required concrete color and compressive strength. Precast concrete bar supports can also be furnished in other sizes needed for unusual project conditions, by special arrangement with the Supplier.

Precast concrete bar supports provide maximum rust protection, i.e., Class 1.

3.4. All-Plastic Bar Supports

The industry practices presented in this section are intended to serve as a guide for the selection and utilization of all-plastic bar supports used to position reinforcing bars in reinforced concrete.

All-plastic bar supports may have a snap-on action or other method of attachment. All-plastic supports are lightweight, non-porous and chemically inert in concrete. Properly designed all-plastic bar supports should have rounded seatings to avoid punching holes in the formwork and should not deform under load when subjected to normal temperatures encountered in use nor should they shatter or severely crack under impact loading when used in cold weather.

According to one report, since all-plastic bar supports are subject to temperature effects, they should have at least 25% of their gross plane area perforated to compensate for the difference in the coefficient of thermal expansion between the plastic and concrete.* Also according to this same report, all-plastic supports should not be placed closer than 12 inches [300 mm] apart along a reinforcing bar.

All-plastic bar supports will not rust, therefore eliminating blemishes on the surface of the concrete. These supports are particularly suitable in situations of moderate to severe exposure or when grinding of the concrete is necessary. All-plastic supports may be used to support epoxy-coated reinforcing bars (see Section 3.6). These bar supports provide maximum rust protection, i.e., Class 1.

The types and sizes of all-plastic bar supports that are generally available are shown in Table 3-4.

3.5. Side-Form Spacers

A side-form spacer is a type of bar support which is used to maintain side concrete cover on the reinforcing bars against a vertical form, such as for walls and piers. Spacers can also be used to align a reinforcing bar cage in a drilled shaft. Spacers can be made of steel wire, precast concrete, or plastic. Precast concrete side-form spacers for caisson applications are generally furnished with multiple sets of wires to minimize support movement when positioned. As noted in Section 3.4, because all-plastic side-form spacers are subject to temperature effects, they should have at least 25% of their gross plane area perforated to compensate for the difference in the coefficient of thermal expansion between the plastic and concrete. Examples of side-form spacers are SBC wire bar supports, DSSS and DSWS precast concrete bar supports, and WS, DSWS and VLWS all-plastic bar supports.

3.6. Recommendations for Bar Supports for Epoxy-Coated Reinforcing Bars

Epoxy-coated reinforcing bars are widely used as a corrosion-protection system for reinforced concrete structures. Compatible types of bar supports should be used to support epoxy-coated reinforcing bars.

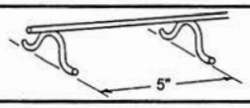
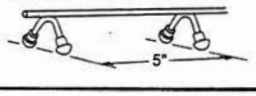
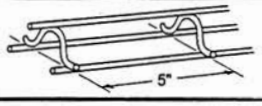
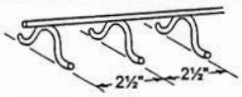
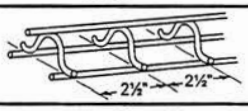
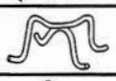
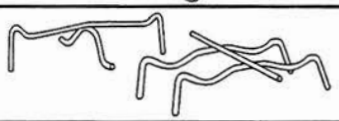
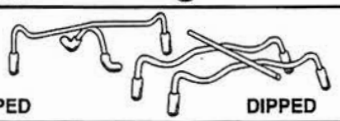
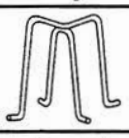
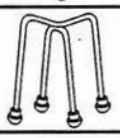
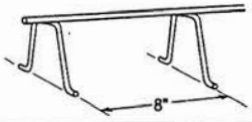
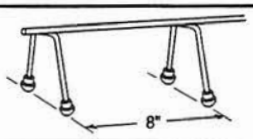
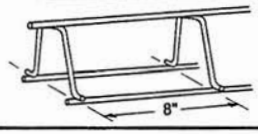
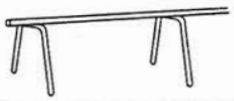
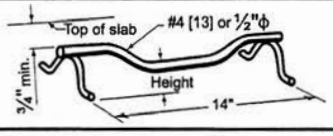
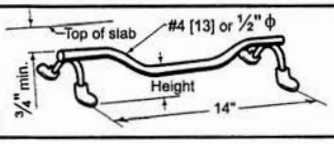
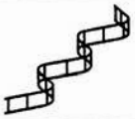
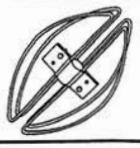
1. Wire bar supports should be coated entirely with dielectric material such as epoxy or plastic, compatible with concrete, or;
2. Bar supports should be made of dielectric material such as plastic or precast concrete; if precast concrete blocks with embedded tie wires or precast concrete doweled blocks are used, the wires or dowels should be epoxy-coated or plastic-coated; or;

*"Selection of Bar Spacers for Reinforced Concrete" by M. Levitt and M.R. Herbert, Concrete, November 1968, Cement and Concrete Association, London. [In the UK, the term "spacers" covers "bar supports" and "side-form spacers".]

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

TABLE 3-1 TYPICAL TYPES AND SIZES OF WIRE BAR SUPPORTS

SYMBOL	BAR SUPPORT ILLUSTRATION	BAR SUPPORT ILLUSTRATION PLASTIC CAPPED OR DIPPED	TYPE OF SUPPORT	TYPICAL SIZES
SB		 CAPPED	Slab Bolster	¾, 1, 1½, and 2 in. heights in 5 ft and 10 ft lengths
SBU*			Slab Bolster Upper	Same as SB
BB		 CAPPED	Beam Bolster	1, 1½, 2 to 5 in. heights in increments of ¼ in. in lengths of 5 ft
BBU*			Beam Bolster Upper	Same as BB
BC		 DIPPED	Individual Bar Chair	¾, 1, 1½, and 1¾ in. heights
JC		 DIPPED DIPPED	Joist Chair	4, 5, and 6 in. widths and ¾, 1 and 1½ in. heights
HC		 CAPPED	Individual High Chair	2 to 15 in. heights in increments of ¼ in.
HCM*			High Chair for Metal Deck	2 to 15 in. heights in increments of ¼ in.
CHC		 CAPPED	Continuous High Chair	Same as HC in 5 ft and 10 ft lengths
CHCU*			Continuous High Chair Upper	Same as CHC
CHCM*			Continuous High Chair for Metal Deck	Up to 5 in. heights in increments of ¼ in.
JCU**		 DIPPED	Joist Chair Upper	14 in. span; heights –1 in. thru +3½ in. vary in ¼ in. increments
CS			Continuous Support	1½ to 12 in. in increments of ¼ in. in lengths of 6'-8"
SBC			Single Bar Centralizer (Friction)	6 in. to 24 in. diameter

*Usually available in Class 3 only, except on special order.
**Usually available in Class 3 only, with upturned or end-bearing legs.

1 in. = 25.4 mm
1 ft = 304.8 mm

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

TABLE 3-2 TYPICAL WIRE SIZES[1] AND GEOMETRY

SYMBOL	NOMINAL HEIGHTS[2]	TYPICAL WIRE SIZES				USUAL GEOMETRY
		CARBON STEEL			STAINLESS STEEL[4]	
		TOP[3]	LEGS	RUNNER	LEGS	
SB	All	4 ga.	6 ga.	N/A	8 ga.	Legs spaced 5 in. on center.
SBU	All	4 ga.	6 ga.	7 ga.	—	Same as SB
BB	Up to 1½ in. incl Over 1½ in. to 2 in. incl Over 2 in. to 3½ in. incl Over 3½ in.	7 ga. 7 ga. 4 ga. 4 ga.	7 ga. 7 ga. 4 ga. 4 ga.	N/A N/A N/A N/A	9 ga. 8 ga. 7 ga. —	Legs spaced 2½ in. on center.
BBU	Up to 2 in. incl Over 2 in.	7 ga. 4 ga.	7 ga. 4 ga.	7 ga. 4 ga.	— —	Same as BB.
BC	All	N/A	7 ga.	N/A	9 ga.	—
JC	All	N/A	6 ga.	N/A	9 ga.	—
HC	2 in. to 3½ in. incl Over 3½ in. to 5 in. incl Over 5 in. to 9 in. incl Over 9 in. to 15 in. incl	N/A N/A N/A N/A	4 ga. 4 ga. 2 ga. 0 ga.	N/A N/A N/A N/A	7 ga. — — —	Legs at 20° or less with vertical. When height exceeds 12 in., legs are reinforced with welded cross wires or encircling wires.
HCM	2 in. to 5 in. incl Over 5 in. to 9 in. incl Over 9 in. to 15 in. incl	N/A N/A N/A	4 ga. 2 ga. 0 ga.	N/A N/A N/A	— — —	Same as HC. The longest leg will govern the size of wire to be used.
CHC	2 in. to 3½ in. incl Over 3½ in. to 5 in. incl Over 5 in. to 9 in. incl Over 9 in. to 15 in. incl	2 ga. 2 ga. 2 ga. 2 ga.	4 ga. 4 ga. 2 ga. 0 ga.	N/A N/A N/A N/A	7 ga. — — —	Legs at 20° or less with vertical. All legs 8¼ in. on center maximum, with leg within 4 in. of end of chair, and spread between legs not less than 50% of nominal height.
CHCU	2 in. to 5 in. incl Over 5 in. to 9 in. incl Over 9 in. to 15 in. incl	2 ga. 2 ga. 2 ga.	4 ga. 2 ga. 0 ga.	4 ga. 4 ga. 4 ga.	— — —	Same as CHC
CHCM	Up to 2 in. incl Up to 2 in. incl Over 2 in. to 5 in. incl	4 ga. 2 ga. 2 ga.	6 ga. 4 ga. 4 ga.	N/A N/A N/A	— — —	With 4 ga. top wire, maximum leg spacing is 5 in. on center. With 2 ga. top wire, maximum spacing is 10 in. on center.
JCU	–1 in. to +3½ in. incl (Measured from form to top of middle portion of saddle bar) in ¼ in. increments.	#4 [#13] bar or ½ in. dia	2 ga.	N/A	—	Legs spaced 14 in. on center. Maximum height of JCU at support legs should be slab thickness minus ¾ in.
CS	1½ in. to 7 in. incl 5 in. to 12 in. incl 7½ in. to 12 in. incl	8 ga. 6 ga. 4 ga.	8 ga. 6 ga. 4 ga.	8 ga. 6 ga. 4 ga.	— — —	Legs spaced 6 in. on center, 4 in. on center at bend point. Middle runner used for heights over 7 in.
SBC	6 in.[5] 12 in. to 14 in.[5] 16 in. to 18 in.[5]	N/A N/A N/A	3 ga. 3 ga. 3 ga.	N/A N/A N/A	— — —	—

1 in. = 25.4 mm

[1] Wire sizes are American Steel & Wire gauges.

[2] The nominal height of the bar support is taken as the distance from the bottom of the leg, sandplate or runner wire to the bottom of the reinforcement. Variations of ± ⅛ in. [3 mm] from the stated nominal height are generally permitted by usual construction specifications for tolerances.

[3] Top wire on continuous supports may be straight or corrugated, at the option of the Manufacturer.

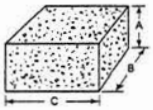
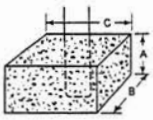
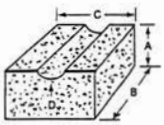
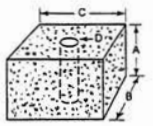
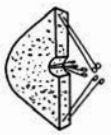
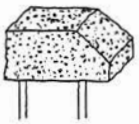
[4] When no wire size is shown for a stainless steel leg, use plain carbon steel legs and attach stainless steel tips to them as noted in Section 3.2.7.

[5] Represents the diameter of the hole where the bar is being centered.

Documents
Document Sharing
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

TABLE 3-3 TYPICAL TYPES AND SIZES OF PRECAST CONCRETE BAR SUPPORTS

SYMBOL	BAR SUPPORT ILLUSTRATION	TYPE OF SUPPORT	TYPICAL SIZES, IN.	DESCRIPTION
PB		Plain Block	A—¾ to 6 B—2 to 6 C—2 to 48	Used when placing bars off grade and formwork. When "C" dimension exceeds 16 in. the block should be cast with a piece of reinforcing bar inside the block.
WB		Wired Block	A—¾ to 4 B—2 to 3 C—2 to 3	Generally, block is cast with embedded 16-gauge tie wire, commonly used against vertical forms or in positions necessary to secure the block by tying to the reinforcing bars.
CB		Combination Block	A—2 to 4 B—2 to 4 C—2 to 4 D—fits #3 to #5 [#10 to #16] bar	Commonly used on horizontal work.
DB		Dowel Block	A—3 B—3 to 5 C—3 to 5 D—hole to accommodate a #4 [#13] bar	Used to support top mat from dowel placed in hole. Block can also be used to support bottom mat.
DSSS		Side-Form Spacer - Wired	Concrete cover, 2 to 6	Used to align the reinforcing bar cage in a drilled shaft.* Commonly 16-gauge tie wires are cast in the spacer. Supports for 5 in. to 6 in. cover have 9-gauge tie wires at top and bottom of the spacer.
DSBB		Bottom Bolster - Wired	Concrete cover, 3 to 6	Used to keep the reinforcing bar cage off of the floor of the drilled shaft.* Support for 6 in. concrete cover is actually 8 in. in height with a 2 in. shaft cast in the top of the bolster to hold the vertical bar.
DSWS		Side-form spacer for drilled shaft applications	Concrete cover, 3 to 6	Generally used to align reinforcing bar in a drilled shaft.* Commonly manufactured with two sets of 12-gauge annealed wires, assuring proper clearance from the shaft wall surface.

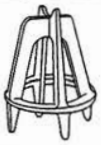
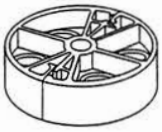
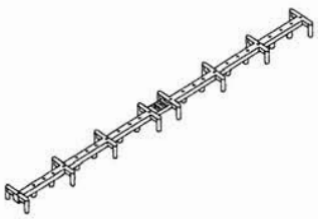
* Also known as a pier, caisson or cast-in-drilled hole.

1 inch = 25.4 mm

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

TABLE 3-4 TYPICAL TYPES AND SIZES OF ALL-PLASTIC BAR SUPPORTS

SYMBOL	BAR SUPPORT ILLUSTRATION	TYPE OF SUPPORT	TYPICAL SIZES, IN.	DESCRIPTION
BS		Bottom Support	Heights, ¾ to 6	Generally for horizontal work. Not recommended for ground or exposed aggregate finish.
BS-CL		Bottom Support	Heights, ¾ to 2	Generally for horizontal work, provides bar clamping action. Not recommended for ground or exposed aggregate finish.
HC		High Chair	Heights, ¾ to 5	For use in slabs or panels.
HC-V		High Chair, Variable	Heights, 2½ to 6¼	For horizontal and vertical work. Provides for different heights.
WS		Wheel Side-Form Spacer	Concrete cover, ⅜ to 3	Generally for vertical work. Bar clamping action and minimum contact with forms. Applicable for column reinforcing bars.
DSWS		Side-Form Spacer for drilled shaft applications	Concrete cover, 2½ to 6	Generally used to align reinforcing bars in a drilled shaft.* Two-piece wheel that closes and locks on to the tie or spiral assuring proper clearance from the shaft wall surface.
VLWS		Locking Wheel Side-Form Spacer for all vertical applications	Concrete cover, ¾ to 6	Generally used in both drilled shaft* and vertical applications where heavy loading occurs. Surface spines provide minimal contact while maintaining required tolerance.
DSBB		Bottom Bolster (Gripping)	Concrete cover, 3 Height, 6	Used to keep the reinforcing bar cage off of the bottom floor of a drilled shaft.* Fits #6 through #11 [#19 through #36] reinforcing bars.
SB		Slab Bolster	Heights, ¾ to 3 Lengths up to 32**	Commonly used in horizontal and vertical applications. When used as a side-form spacer in vertical work, slab bolster must be tied to the reinforcement.

* Also known as a pier, caisson or cast-in-drilled hole.
** Pieces can be locked together to form longer lengths.

1 inch = 25.4 mm

AVA Documents Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

3. Reinforcing bars that are used as support bars should be epoxy-coated. In walls reinforced with epoxy-coated bars, spreader bars where specified by the Architect /Engineer, should be epoxy-coated. Proprietary combination bar clips and spreaders that are used in walls with epoxy-coated reinforcing bars should be made of corrosion-resistant material or coated with dielectric material.

For epoxy-coated and plastic-coated wire bar supports:

1. Repair of damaged coating—the repair of damaged coating, when required, should be made with patching material and done in accordance with the patching material manufacturer's recommendations; the patching material should be compatible with the epoxy-coating material or plastic-coated material, and be inert in concrete. It should not be expected that epoxy-coated or plastic-coated wire bar supports will be completely free of damaged coating. Hanger marks on the coated bar supports, resulting from the coating application process, are acceptable and should not be considered as damaged coating.
2. Inspection—all tests and inspections are normally made at the manufacturer's facility prior to shipment, unless otherwise specified.

3.7. Placing Bar Supports

3.7.1 Application and Use of Bar Supports*

Bar supports are generally estimated and furnished for all formed beams, girders, joists and slabs as shown in the following recommended details, unless otherwise specified on the project drawings or in the project specifications.

When wire bar support units are placed in continuous lines, they are usually placed so that the ends of the supporting wires can be lapped to lock the last legs on adjoining units. Reinforcing bars are not normally placed more than 2 inches [50 mm] beyond the last leg at the end of a run of any continuous support.

Bar supports are generally furnished for the top bars only in slabs on ground** 4 feet [1200 mm] or less in thickness. The average spacing of the bar supports should not exceed 4 feet [1200 mm] in each direction. For some available types of bar supports, see Section 3.14.2. Support bars are not normally furnished, as principal reinforcement is used for support.

In certain regions of the USA, bar supports are not generally furnished by the reinforcing steel supplier for bottom bars in grade beams, slabs on ground, bars in singly reinforced*** slabs on ground, or for column or wall footings. Bar supports are not normally furnished for top bars in foundation mats more than 4 feet [1200 mm] in thickness. Since there are many ways of supporting such bars, Suppliers generally furnish supports for such purposes only by special arrangement.

Similarly, bar supports are not normally furnished by the reinforcing steel supplier for supporting welded wire fabric except by special arrangement or unless otherwise specified on the project drawings or in the project specifications.

Historically, it has been industry practice in certain regions of the country to not furnish bar supports to space or support reinforcing bars in walls, columns, sides of beams, or for any other special conditions not covered in the following recommended details. However, examination of exposed concrete surfaces without side-form spacers often reveals spalling of the concrete and mislocated reinforcement. If the concrete cover on the reinforcement is less than that specified, early deterioration and spalling of such exposed surfaces can be expected to occur. Maintaining the proper concrete cover on the reinforcement, as is done for slabs, can be accomplished for vertical surfaces by use of side-form spacers. If the General Contractor desires to use side-form spacers, special arrangements should be made with the reinforcing steel supplier (see Section 5.16 in Chapter 5).

It is industry practice to not furnish bar supports for temperature-shrinkage reinforcement in top slabs of concrete joist construction unless specified on the project drawings or in the project specifications, or otherwise mutually agreed between Buyer and Seller of reinforcing steel.

Bar supports are intended to support the steel reinforcement and normal construction loads. **Bar supports are not intended to support hoses for concrete pumps, or runways for concrete buggies or similar loads.**

*Further information on placing reinforcing bars and bar supports can be found in the publication *Placing Reinforcing Bars* available from the Concrete Reinforcing Steel Institute.

**"Slabs on ground" include slabs cast either directly upon the ground or upon unreinforced concrete fill used as a leveling course (mud mat).

***Singly reinforced slabs on ground contain reinforcement, usually for shrinkage and temperature, at one level, in one or both directions.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

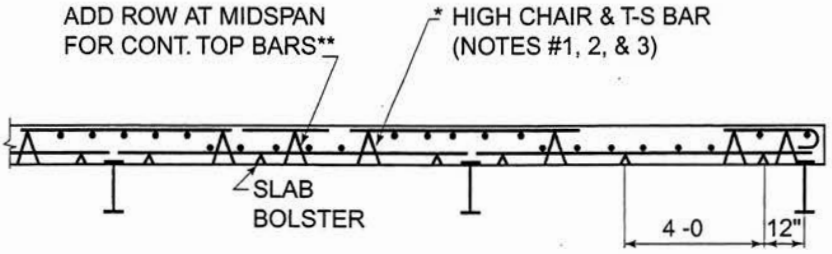
BAR SUPPORTS

3.7.2 Recommended Details and Placing Sequences

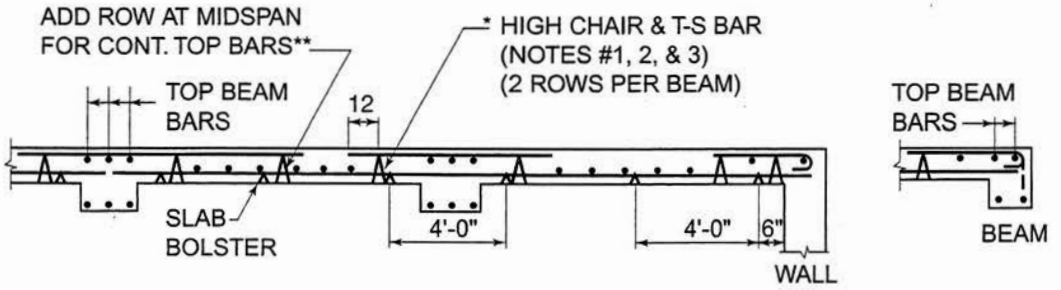
Industry practices for placing reinforcing bars and bar supports vary within the USA. The following drawings and descriptions of bar supports are intended to be a generic presentation of the various types of wire, precast concrete, and all-plastic bar supports. Depending on regional placing practices, any of the types of bar supports are regarded as being appropriate for supporting reinforcing bars in reinforced concrete structural members — provided the bar supports maintain the required concrete cover and do not deform under normal construction loads.

Bar supports will generally be furnished in accordance with the following recommended details and placing sequences.

3.8. One-Way Solid Slabs



SLAB ELEVATION



1 in. = 25.4 mm; 1 ft = 304.8 mm

SLAB ELEVATION

*Continuous high chairs may be used in lieu of support bars and high chairs.

**Exceptions: Not required if adjacent rows are spaced 4 feet [1200 mm] or less apart. With #3 [#10] continuous top bars provide rows of support at 2 feet [600 mm] on center.

Note: Industry practices for placing reinforcing bars and bar supports vary within the USA. In certain regions of the country, the bar placing subcontractor may prefer to substitute individual bar supports in lieu of slab bolsters. Refer to Section 3.7.2 for use of various types and materials of bar supports.

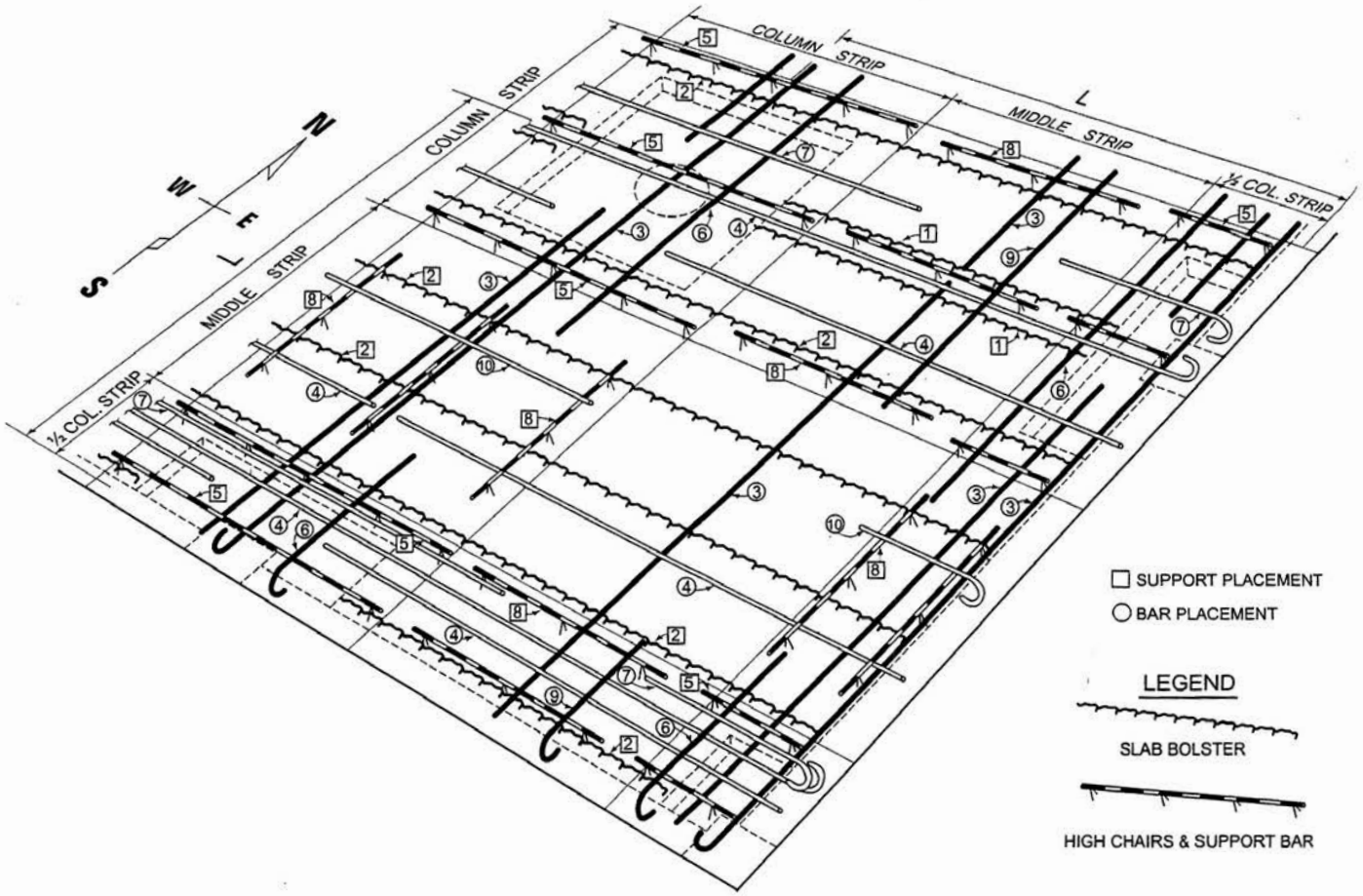
Notes:

1. A line of properly lapped support bars can replace an equal amount of temperature-shrinkage (T-S) reinforcement. T-S bars to be used for supports—Use Class A tension lap splice.
2. For #5 [#16] T-S bars use high chairs at 4 feet [1200 mm] on center. For #4 [#13] T-S bars, use high chairs at 3 feet [900 mm] on center.
3. Do not use #3 [#10] T-S bar for support bar; substitute one #4 [#13] bar (properly lapped) with high chairs at 3 feet [900 mm] on center.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

3.12. Sequence of Placing Bar Supports and Reinforcing Bars in Two-Way Flat Slab



1. Place a single line of slab bolsters in E-W direction on each side adjacent to column centerline between drop panels.
2. Place continuous lines of slab bolsters in E-W direction at 4 feet [1200 mm] maximum on center between drop panels. Begin spacing 3 inches [75 mm] outside drop panels. Add one E-W slab bolster at slab edges between drop panels.
3. Set N-S bottom bars, column and middle strips.*
4. Set E-W bottom bars, column and middle strips.*
5. Place three rows of #4 [#13] support bars (length 0.5L) on high chairs at 3 feet [900 mm] maximum on center in E-W direction at each column head. Tie middle support bar to column vertical bars.
6. Set N-S column strip top bars.
7. Set E-W column strip top bars.
8. Place three or more rows of #4 [#13] support bars (length 0.32L) at 4 feet [1200 mm] maximum on center in N-S and E-W column strips, parallel to the strips. Place two rows at all slab edges.
9. Set N-S top bars in middle strips.
10. Set E-W top bars in middle strip.

Note 1: This sequence is used when the Architect/Engineer does not specify the outermost bar layer direction, usually when spans in each direction are equal. In this case the bottom layer is N-S, the topmost layer is E-W.

Note 2: Industry practices for placing reinforcing bars and bar supports vary within the USA. In certain regions of the country, the bar placing subcontractor may prefer to substitute individual bar supports in lieu of slab bolsters. Refer to Section 3.7.2 for use of various types and materials of bar supports.

*For structural integrity, the ACI 318 Building Code requires that all column strip bottom bars must be made continuous with adjacent spans. If the reinforcing bars must be spliced, a Class A tension lap splice is required and located at the support. Two of these reinforcing must pass through the column core and be placed within the column reinforcement. Note that, in the illustration above, these reinforcing bars have been hooked at the exterior support and that the slab bolsters were extended.

AVA Documents
Document Sharing Hub

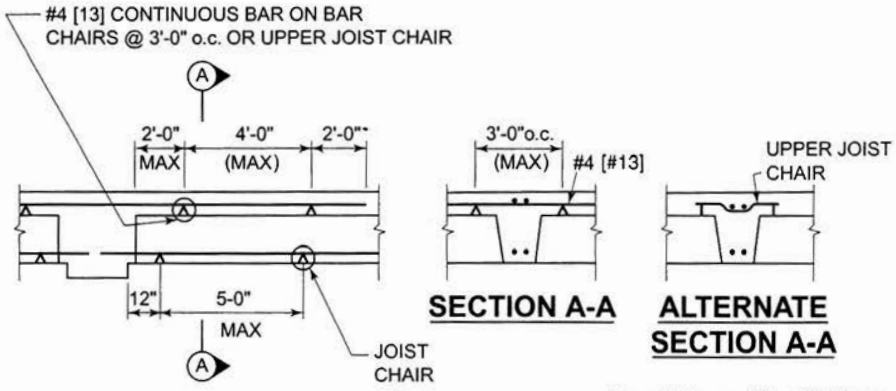
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

3.9. Joists

Bar supports are generally not provided for temperature-shrinkage welded wire fabric or reinforcing bars in concrete joist slabs. It is recommended that temperature-shrinkage bars be tied, and spaced with #3 [#10] bars centered on alternate rows of forms, i.e., about 4'-2" to 6'-0" [1250 to 1800 mm] on center at right angles to temperature-shrinkage bars.

Top bars are normally supported either by bars on individual chairs or by upper joist chairs.

For two-way joist construction (waffle slabs), the bar supports in the ribs in one direction can usually be made the same as for one-way concrete joist construction. Bar supports can be omitted in ribs at right angles as these bars are supported on the bottom bars running in the first direction, except top bars in the middle strips.



1 in. = 25.4 mm; 1 ft = 304.8 mm

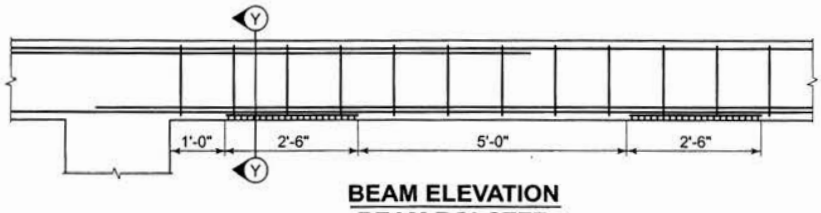
JOIST ELEVATION



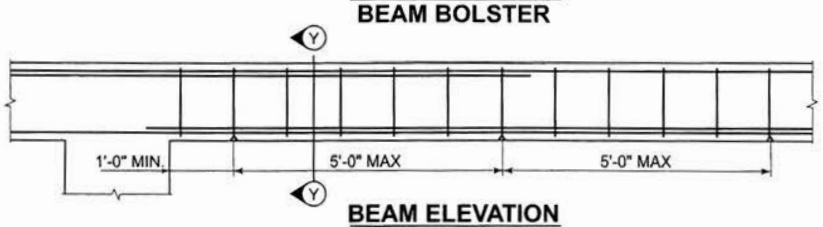
UPPER JOIST CHAIR
Upper joist chair is available on special order only.

3.10. Beams and Girders

Beam and girder reinforcing bars must be adequately supported in the forms to prevent displacement by concrete placement or by workers.

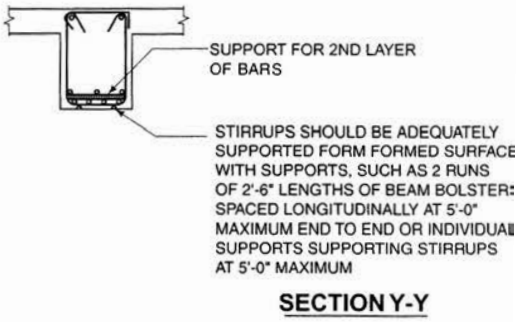


BEAM ELEVATION
BEAM BOLSTER



BEAM ELEVATION
INDIVIDUAL SUPPORTS

1 in. = 25.4 mm; 1 ft = 304.8 mm



SECTION Y-Y

Documents
Document Sharing Hub

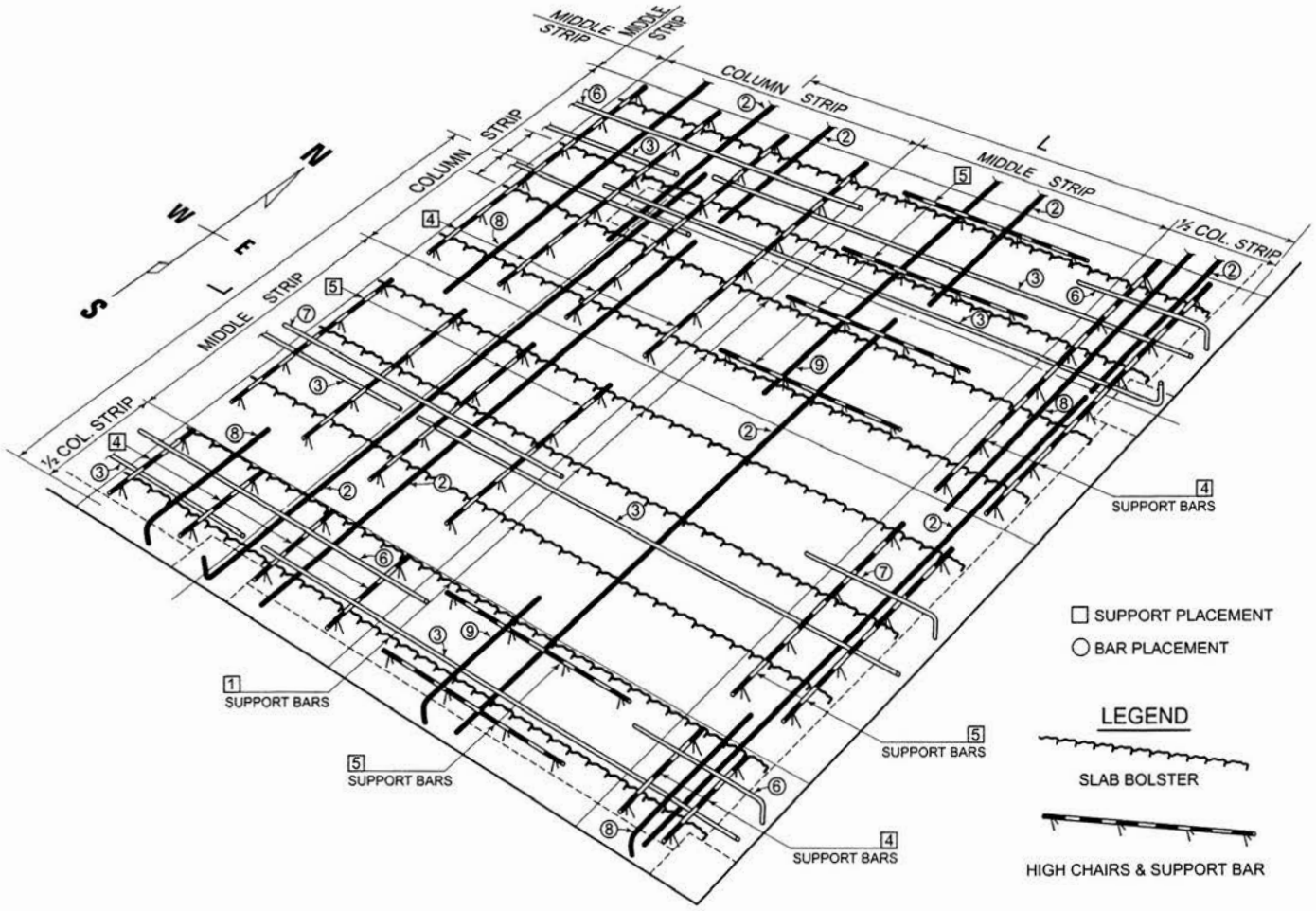
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

3.11. Sequence of Placing Bar Supports and Reinforcing Bars in Two-Way Flat Plate



1. Place continuous lines of slab bolsters in E-W direction at 4 feet [1200 mm] maximum on center between columns.
2. Set N-S bottom bars in column and middle strips.*
3. Set E-W bottom bars in column and middle strips.*
4. Place three or more rows of #4 [#13] support bars (length 0.5L) at 4 feet [1200 mm] maximum on center on high chairs at 3 feet [900 mm] maximum on center in N-S direction at each column head.
5. Place three or more rows of #4 [#13] support bars (length approx. 0.4L) at 4 feet [1200 mm] maximum on center on high chairs at 3 feet [900 mm] maximum on center between columns lengthwise in N-S and E-W column strips.
6. Set E-W top column strip bars at column heads.
7. Set E-W top middle strip bars.
8. Set N-S top column strip bars at column heads.
9. Set N-S top middle strip bars.

Note 1: This sequence is used when the Architect/Engineer specifies the outmost layer direction. In this case, the N-S bars are closest to the bottom and top of slab.

Note 2: Industry practices for placing reinforcing bars and bar supports vary within the USA. In certain regions of the country, the bar placing subcontractor may prefer to substitute individual bar supports in lieu of slab bolsters. Refer to Section 3.7.2 for use of various types and materials of bar supports.

*For structural integrity, the ACI 318 Building Code requires that all column strip bottom bars must be made continuous with adjacent spans. If the reinforcing bars must be spliced, a Class A tension lap splice is required and located at the support. Two of these reinforcing bars must pass through the column core and be placed within the column reinforcement. Note that, in the illustration above, these reinforcing bars have been hooked at the exterior support and that the slab bolsters were extended.

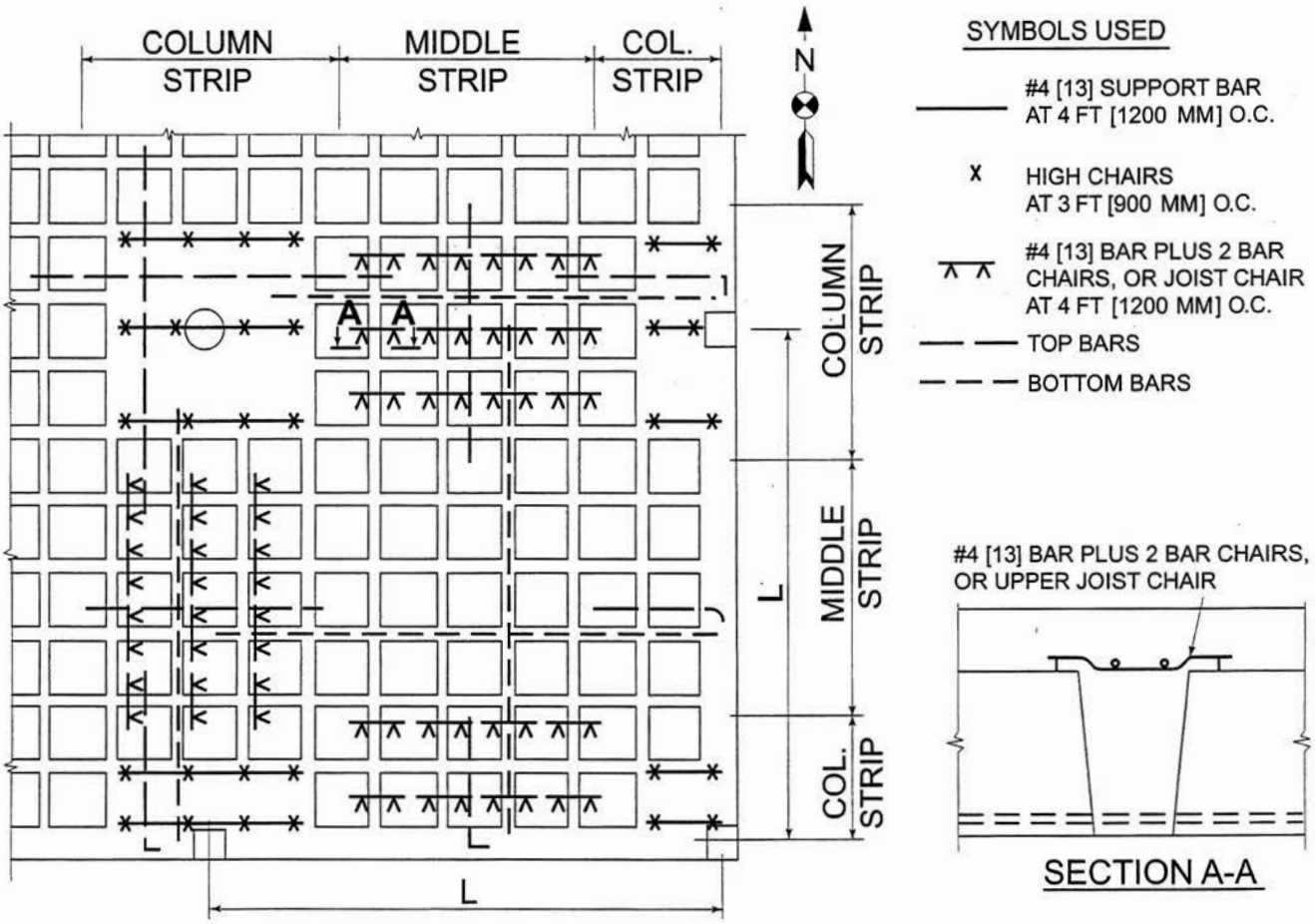
AVA Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

3.13. Sequence of Placing Bar Supports and Reinforcing Bars in Two-Way Waffle Flat Slab



1. Place standard joist chairs in joist rib bottom at 5 feet [1500] on center in N-S column strip and N-S middle strip (full length).
2. Set N-S column and middle strip bottom bars.*
3. Set E-W column and middle strip bottom bars.*
4. At column heads, place three (or more) rows of #4 [#13] support bars (length full width of column head) on high chairs at 3 feet [900 mm] one center in E-W direction.
5. Set N-S column strip bars.
6. Place #4 [#13] bar plus two bar chairs (or upper joist chair) at 4 feet [1200 mm] on center in N-S and E-W middle strip. If top bars are spaced over the entire middle strip, use #4 [#13] support bars at 4 feet [1200 mm] on center with bar chairs at 3 feet [900 mm] on center
7. Set N-S and E-W middle strip top bars.
8. Set E-W column strip top bars; tie column strip N-S bars to support bars; tie column strip E-W bars to N-S bars.

Note 1: Industry practices for placing reinforcing bars and bar supports vary within the USA. In certain regions of the country, the bar placing subcontractor may prefer to substitute individual bar supports in lieu of slab bolsters. Refer to Section 3.7.2 for use of various types and materials of bar supports.

*For structural integrity, the ACI 318 Building Code requires that all column strip bottom bars must be made continuous with adjacent spans. If the reinforcing bars must be spliced, a Class A tension lap splice is required and located at the support. Two of these reinforcing bars must pass through the column core and be placed within the column reinforcement. Note that, in the illustration above, these reinforcing bars have been hooked at the exterior support.

AVA Documents
Document Sharing

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

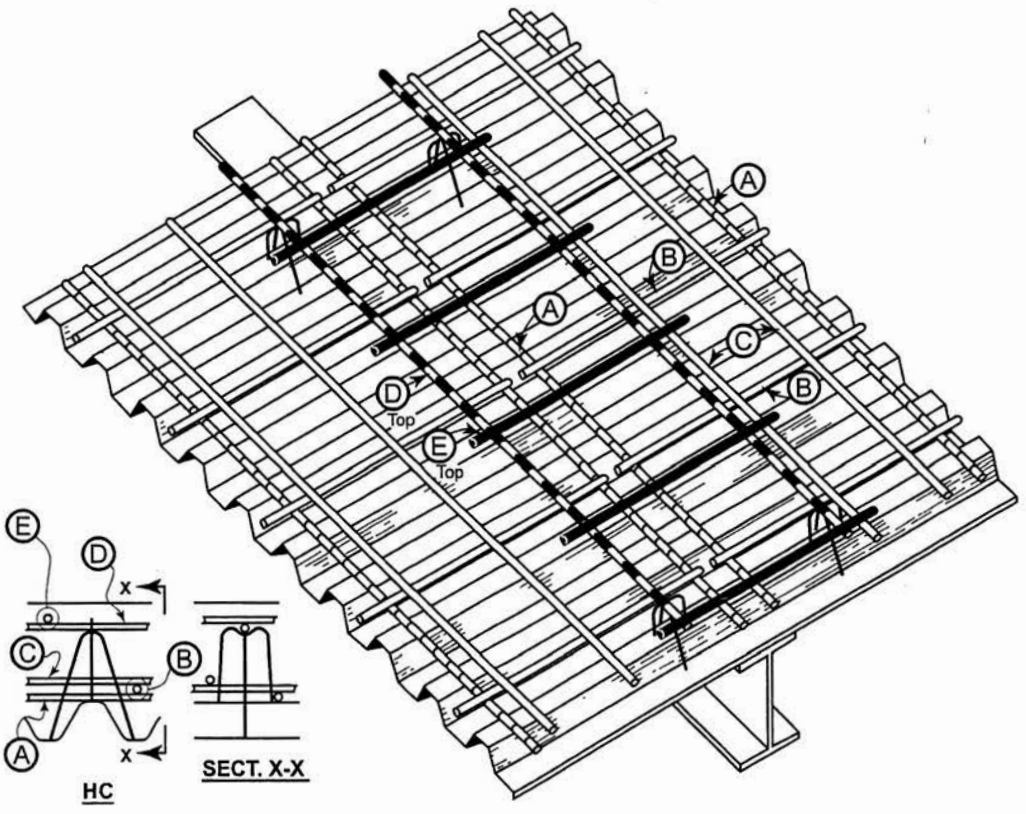
3.14. Bar Supports For Special Conditions

3.14.1 One-Way Slabs on Corrugated Steel Forms—Placing Sequence

1. Place corrugated steel forms and fasten to supporting members.
2. Set #3 [#10] support bars (A) at 5 feet [1500 mm] on steel forms.
3. Set main reinforcing bars (B) (positive moment reinforcement) over valleys. Tie to support bars. Spacing of main bars should be a multiple of steel form pitch.
4. Set temperature-shrinkage bars (C). Tie to main bars.
5. Place individual high chairs at 3 feet [900 mm] on center* For continuous top bars, place extra row of high chairs at midspan.
6. Place #4 [#13] support bars (D) on chairs. (A line of properly lapped support bars can replace an equal amount of temperature-shrinkage reinforcement.)
7. Set top bars (E) (negative moment reinforcement). Tie to support bars.

*Continuous high chairs may be used in lieu of support bars and high chairs.

NOTE: Refer to Section 3.7.2 for use of various types and materials of bar supports.



Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

BAR SUPPORTS

3.14.2 Foundation Mats and Slabs on Ground or on Mud-Mat

Spacing of bar supports for slabs on ground or on mud-mat follows the recommendations in Sections 3.7 through 3.15, adjusted for the particular conditions of weight and rigidity of the reinforcing steel specified.

Bar supports indicated are generally estimated and furnished for slabs up to 4 feet [1200 mm] thick unless otherwise specified on the project drawings or in the project specifications.

Examples of bar supports for foundation mats and slab on ground:

Plain Concrete Block—Heights to 6 inches [152 mm].

All-Plastic Chair with Base Plate—Heights to 5 inches [127 mm].

HCP—An individual high chair with sand plate for soil bearing. Heights to 15 inches [381 mm].

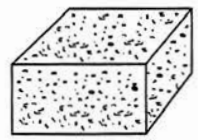
CHCU—Continuous high chair upper. Continuous runner wires provide for support off lower mat of reinforcing bars. Heights up to 15 inches [381 mm].

Standee—A reinforcing bar fabricated to order with the bent legs resting on lower mat of bars.

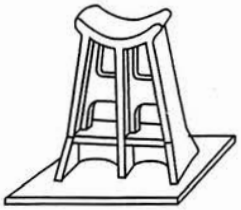
Dowel Block—A precast block with hole for #4 [#13] dowel bar. Suitable for support of both top and bottom mats of bars. Heights to 2 feet [610 mm].

Recommended practice for usage for slabs of total thickness:

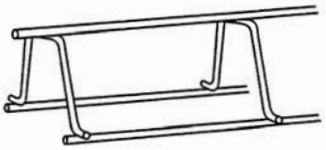
1. 2 feet [600 mm] or less—HCP, Plain Concrete Block, All-Plastic Chair with Base Plate, CHCU, Standees using #4 [#13] bars, or dowel blocks (Western States only).
2. More than 2 feet [600 mm] and up to 4 feet [1200 mm]—Standees using #5 [#16] bars.
3. More than 4 feet [1200 mm]—Bar supports are generally not furnished except by special arrangement.



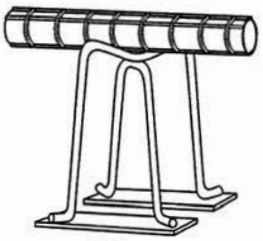
Plain Concrete Block



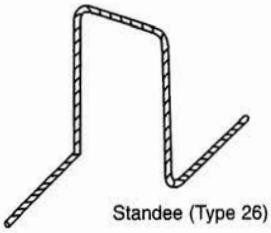
All-Plastic Chair With Base Plate



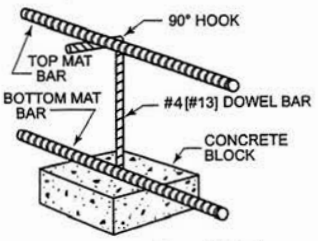
CHCU



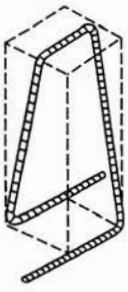
HCP



Standee (Type 26)



Dowel Block



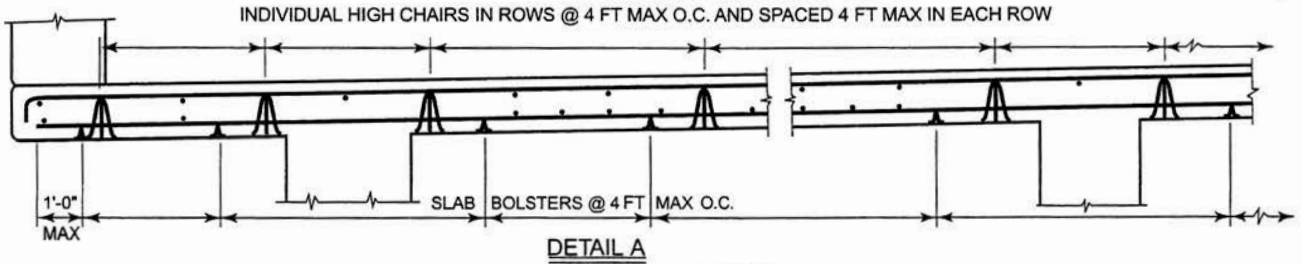
Standee (Type 25)

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

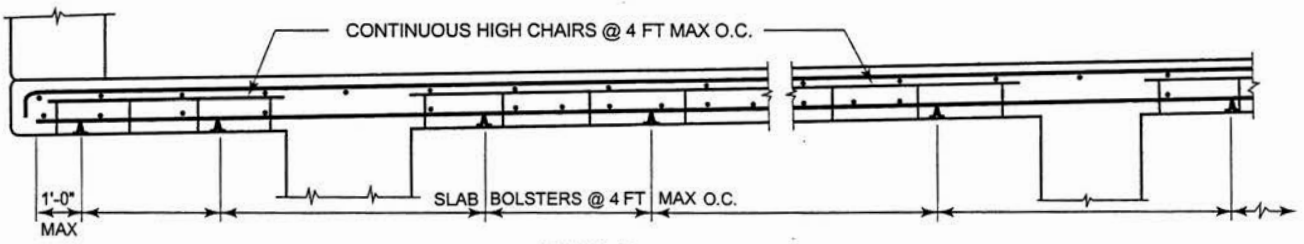
BAR SUPPORTS

3.15. Bar Supports For Highway Bridge Slab Reinforcement

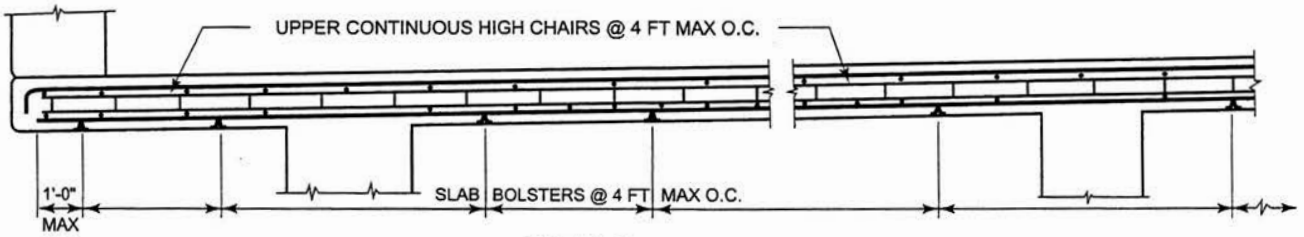
3.15.1 Slabs on Flat Formwork



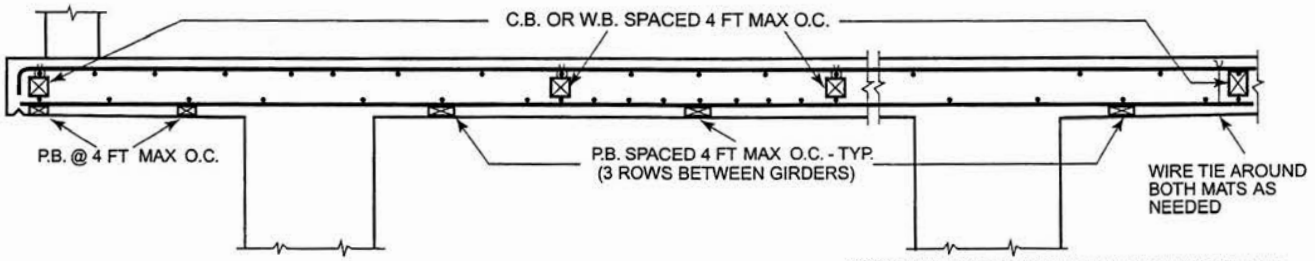
DETAIL A
SHOWING INDIVIDUAL HIGH CHAIRS



DETAIL B
SHOWING CONTINUOUS HIGH CHAIRS



DETAIL C
SHOWING UPPER CONTINUOUS HIGH CHAIRS



P.B.: PLAIN PRECAST CONCRETE BAR SUPPORT
W.B.: PRECAST CONCRETE BAR SUPPORT WITH WIRES
C.B.: COMBINATION bLOCK

DETAIL D
SHOWING PRECAST CONCRETE BAR SUPPORTS

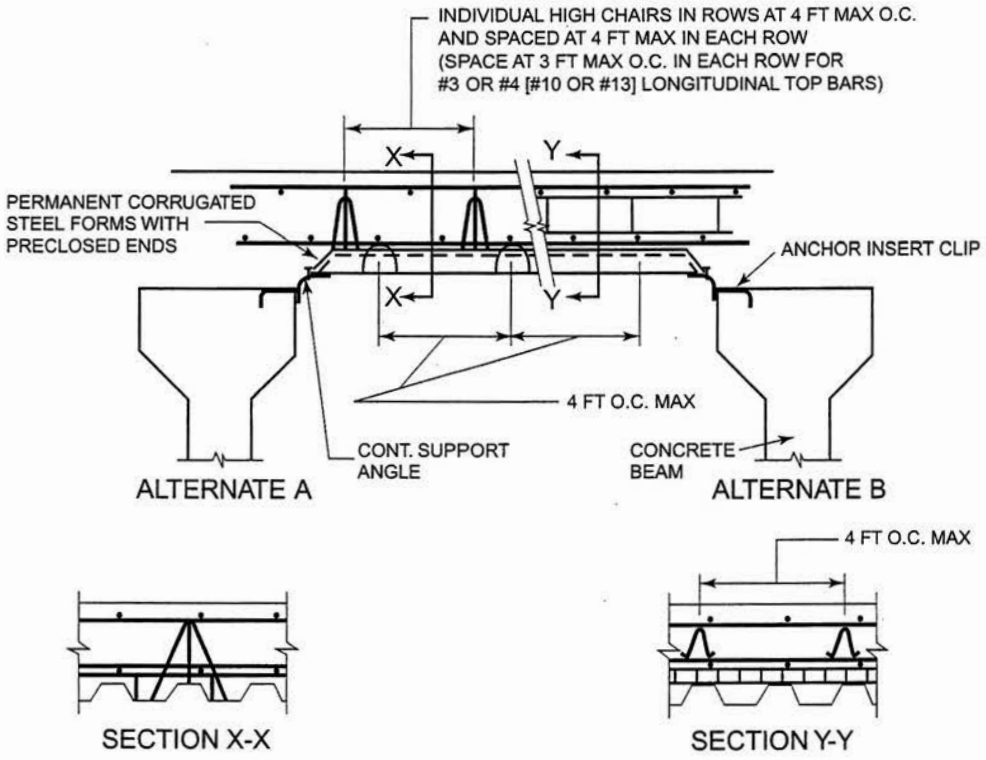
GIRDER STIRRUPS AND THEIR TOP BARS THAT EXTEND SUFFICIENTLY INTO THE BRIDGE DECK CAN BE USED TO SUPPORT THE TOP SLAB REINFORCEMENT, THEREBY ELIMINATING THE NEED FOR TOP AND BOTTOM LONGITUDINAL SLAB BARS WITHIN THE GIRDERS AND ANY TOP BAR SUPPORTS ADJACENT TO THE GIRDERS.

1 ft = 304.8 mm

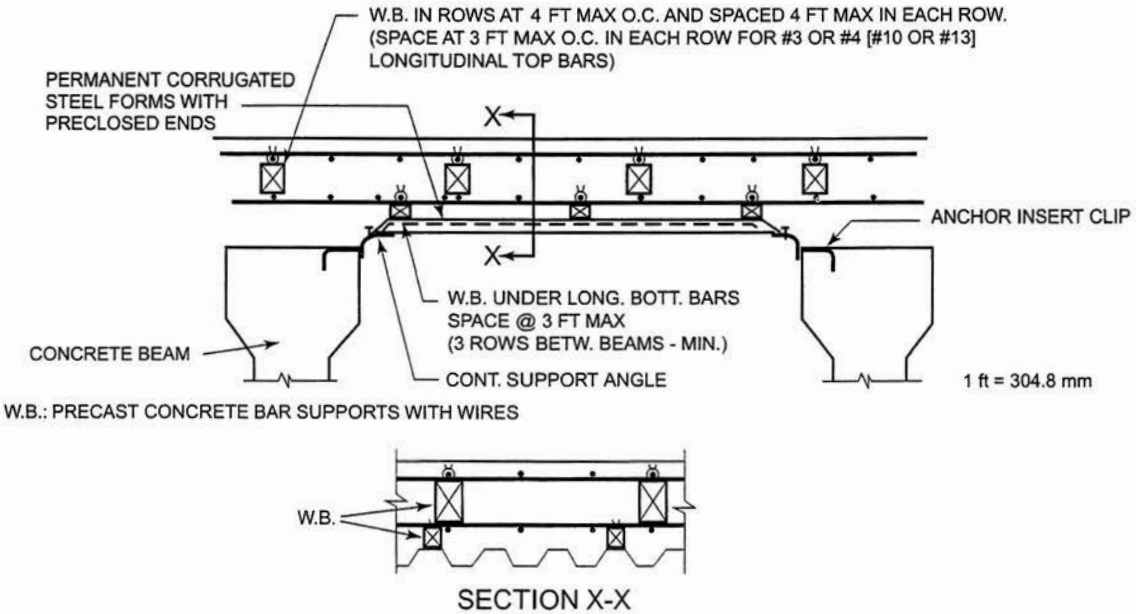
Note: Industry practices for placing reinforcing bars and bar supports vary within the USA. In certain regions of the country, the bar placing subcontractor may prefer to substitute individual bar supports in lieu of slab bolsters. Refer to Section 3.7.2 for use of various types and materials of bar supports.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

3.15.2 Slabs on Permanent Corrugated Steel Forms



WIRE BAR SUPPORTS ON PERMANENT STEEL FORMS



PRECAST CONCRETE BAR SUPPORTS ON PERMANENT STEEL FORMS

Note: Refer to Section 3.7.2 for use of various types and materials of bar supports.

AVA Documents Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

CHAPTER 4

NOTES TO ARCHITECT/ENGINEER

4.1. Introduction

The recommendations in this chapter are intended to assist the Architect/Engineer in achieving economy in the design and construction of reinforced concrete structures. Also included in this Chapter are "Suggested Specifications for Reinforcing Steel" starting on page 4-8, in which minimum requirements for furnishing, fabricating, and placing reinforcing steel are presented.

4.2. Recommended Industry Practices

The Architect/Engineer should examine Chapters 5, 6, 7, 8, and 10 of this *Manual* to become familiar with the current practices and customs of the reinforcing steel industry.

4.3. Sizes of Reinforcing Bars and Spirals

It is recommended that the standard sizes of reinforcing bars and spirals be used, as listed in Chapter 1 of this *Manual*. The number of different bar sizes used in a structure should be held to a minimum.

Although not generally carried in regular stock by Fabricators, the largest size bars #14 and #18 [#43 and #57] are available in Grades 60 and 75 [420 and 520] under the ASTM A615/A615M Specification and in Grade 60 [420] under the ASTM A706/A706M Specification, and may be secured upon advance arrangement with suppliers.

For those design situations requiring heavy concentration of reinforcement, bundles of reinforcing bars may be used. #14 and #18 [#43 and #57] bars should not be bundled in beams or girders. Standard end hooks, if required in bundles, should be staggered.

4.4. Grade or Minimum Yield Strength Designation

The following grades or minimum yield strength designations are currently provided by the ASTM specifications:

- Grades 40, 60 and 75 [300, 420 and 520] in billet-steel (A615/A615M);
- Grade 60 [420] in low-alloy steel (A706/A706M);
- Grades 40 and 60 [300 and 420] in axle-steel (A996/A996M);
- Grades 50 and 60 [350 and 420] in rail-steel (A996/A996M).

The grade numbers indicate minimum yield strength in kips/in.^{2} [megapascals], based on the nominal cross-sectional area of reinforcing bars.

Except for low-alloy steel reinforcing bars (A706/A706M), the grade of billet-steel (A615/A615M) and rail-steel and axle-steel (A996/A996M) reinforcing bars must be specified by the Architect/Engineer. Where more than one grade is required in the project, the Architect/Engineer must indicate on the project drawings or in the project specifications where each grade is to be used.

For maximum economy, the use of billet-steel reinforcing bars conforming to ASTM A615/A615M, Grade 60 [420] is recommended.

Rail-steel and axle-steel reinforcing bars are not generally available except in a few areas of the country. In those areas where such bars are currently available, not all bar sizes and grades per the ASTM specifications are produced and furnished. Before specifying A996/A996M reinforcement, local availability should be investigated.

Requirements in project specifications more restrictive than the ASTM standard specifications for reinforcing bars will usually reduce availability and increase costs. Such requirements should be clearly specified. This will enable the Contractor to investigate availability of reinforcing bars in advance and to avoid mistakes at the time of ordering.

4.5. Standard Notation

To avoid any misinterpretation in designating the type of reinforcement, required sizes of reinforcing steel and related items should be designated as follows on the project drawings and project specifications:

1. Deformed reinforcing bar sizes are referred to by number; for example, #3 [#10], #4 [#13], #5 [#16], etc.
2. Plain bar sizes are indicated by fractions of an inch; for example, 3/8 dia, 1/2 dia, 5/8 dia.
3. Epoxy-coated reinforcing bars should be identified with a suffix (E) and a note stating that all bars identified as such are to be epoxy-coated. A suffix (G) would be appropriate for identifying zinc-coated (galvanized) reinforcing bars.
4. Plain wire is denoted by the letter W [MW] followed by a number indicating the cross-sectional area of the wire. Deformed wire is similarly denoted by the letter D [MD] followed by a number indicating the wire's cross-sectional area.
5. Welded plain wire fabric is indicated as discussed in Chapter 2. For example:

   WWF 6 ×12—W16 × W8
   [WWF 152 × 305—MW100 × MW50]

   Welded deformed wire fabric would be designated in the same manner with the appropriate D [MD] number wire size. Thus:

   WWF 6 × 12—D16 × D8
   [WWF 152 × 305—MD100 × MD50]

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

NOTES TO ARCHITECT/ENGINEER

4.6. Project Drawings

The following recommendations concerning information that should be included on project drawings are presented to help achieve practical reinforcing bar details in conformance with the ACI Building Code, and thus obtain maximum economy in site-cast reinforced concrete construction.

1. Use the terms "similar" and "typical" with caution. It is preferable to indicate differences between the detail drawn and "similar" or "typical" details, using separate sketches.
2. When more than one grade of reinforcing bar is required for the project, show where each grade is used.
3. Use the typical bar bends and ACI standard end hooks as shown in Chapter 6.
4. Where straight and/or bent bars are to be alternated, indicate spacing as follows: #4 @ 10" [#13 @ 250 mm] alt. str. and/or bent", which indicates a spacing of 10 inches [250 mm] for adjacent bars.
5. The ACI Building Code requires the Architect/Engineer to indicate the type and location of all splices. Projects are usually bid by both the Fabricator and the Placer based on the splice locations as shown. Splices may be added later to accommodate formwork or special job-site requirements. The Architect/Engineer should review the added splices as he or she will be requested to approve them. See Section 4.15 for further notes on splice information required on project drawings or in project specifications.
6. The ACI Building Code requires the Architect/Engineer to indicate the anchorage or embedment lengths for all reinforcement.
7. When concrete cover is given for reinforcement in beams and columns, it should be specified whether the cover is to stirrups, ties, or hoops or to main reinforcing bars.
8. When beams and joists or slabs intersect in the same plane, indicate clearances required to allow passage of reinforcing bars. Bar clearances should also be indicated at the intersections of beams and columns.
9. Where skewed sections are not symmetrical or develop into flared sections, or both, the use of straight reinforcing bars, top and bottom, would be more economical to detail, fabricate and place as opposed to the use of truss-bent bars of graduated lengths.
10. All concrete and masonry requiring reinforcing bars or welded wire fabric should be shown on the project drawings.
11. Where temperature–shrinkage reinforcement is required, it should be indicated on the project drawings by bar size and spacing. If welded wire fabric is required, the style of fabric should be indicated on the project drawings. According to standard industry practice, where no temperature-shrinkage reinforcement is called for on the project drawings, none will be provided.
12. The Architect/Engineer should indicate on the project drawings, the size, depth and elevation of all footings or foundation mats. When footing dowels are indicated, the dowels furnished will be equal in size and quantity to the column and wall vertical reinforcing bars, unless otherwise specified by the Architect/Engineer.
13. The project drawings should indicate the typical arrangements of reinforcing bars for beams, joists, walls and slabs, including bar cut-offs and all structural integrity reinforcement requirements.
14. If reinforcing bars are required in the corners, they should be specifically shown on the project drawings, as to their location in walls, footings, beams, or other part of the structure.
15. Typical details and notes pertaining to a portion of a structure (e.g., footings or walls) should be shown on that drawing, or if shown on a separate drawing be adequately cross-referenced. Reinforcing bar details should not be mixed, for instance, with structural steel details unless the bars are connected to the structural steel or are required to serve a specific structural purpose.

4.7. Length of Reinforcing Bars

According to standard industry practice, reinforcing bars are sheared to length with a tolerance allowance of ± 1 inch [± 25 mm] for bar sizes #3 through #11 [#10 through #36], and ± 2 inches [± 50 mm] for #14 and #18 [#43 and #57] bars. Where closer tolerances or where finished ends of reinforcing bars are required, the Architect/Engineer should so specify, in which case extra costs may be incurred.

All sizes of bars are generally available in lengths up to 60 feet [18.3 m]. Where required bar lengths exceed 60–foot [18.3-m] lengths, special arrangement between the Producer and the Fabricator is necessary. Practical difficulties, special order to the Producer, and transportation and handling limitations often make the alternative use of lap splices, mechanical splices, or welded splices more feasible. Even though the reinforcing bars can be obtained in long lengths, the Architect/Engineer should consider the difficulties involved in placing the bars and try to limit the bar lengths to 60 feet [18.3 m] or shorter in the design.

Documents
Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

NOTES TO ARCHITECT/ENGINEER

4.8. Beams and Girders

As far as practicable the spacing, widths and, especially, the overall depths of beams and girders should be uniform throughout the structure. To determine suitable widths and depths, in addition to relative costs of reinforcing bars and concrete versus formwork, consideration should be given to overall costs of building height, and level ceilings affected by depths selected for beams and girders.

Where closed stirrups are required, costs will usually be reduced by using two-piece stirrups to facilitate field placement.

4.9. Joist Construction

Maximum economy through the use of removable forms for joist construction is achieved by maximum reuse of standard forms in the same layout for each floor and the roof, and the same depth and size of forms throughout. Use heavier reinforcement for the longer spans and thinner top slab for the lighter roof load as necessary. Further saving in overall building height and in simpler forming can be achieved with one-way joists by using uniform depth joist-band construction; that is, with supporting beams the same depth as the joists. Two-way joist construction (waffle slab) can readily utilize a uniform depth for two-way flat plate design. Where utilized in design as a two-way slab supported on four sides, it is usually possible to provide beams at the same depth.

4.10. Flat Plates and Flat Slabs

Where finished ceilings are required, flat plate construction has proved to be economical. Solid flat plate construction for short spans or waffle flat plate construction for longer spans provides a maximum headroom with minimum floor-to-floor height.

Where flat slab construction is used, the dimensions of the column capital and the size of the drop panel should be unchanged throughout the building. The size of the drop panel should be adjusted to provide for slab formwork between drop panels in multiples of 2 feet [600 mm] for efficient use of plywood formwork.

4.11. Post-Tensioned Beams and Slabs

Where post-tensioning is used, the project drawings should clearly show the additional reinforcing steel required:

- Behind slab tendon anchors
- At slab openings
- At closure pour and construction joists
- Behind beam tendon anchors or anchor plates (i.e., grillage reinforcing bars)

Closed stirrups for beams should be two pieces—open stirrups (bend type S3) with stirrup caps (bend type T9). Special attention should be given to the column vertical bar arrangement at beam-column joints to allow enough clearance for the beam tendon anchors or anchor plates to be set into position. Where reinforcing bars are used in conjunction with post-tensioning materials, the placing sequence should be shown on the project drawings, especially in two-way systems.

4.12. Falsework and Form Reuse

The design of the structural concrete framing system should be carried out to provide a maximum amount of reuse with the minimum amount of formwork.

Construction labor-saving techniques which provide for economical movement of forms and falsework can also be provided in the structural design, and should be considered as important as reuse. Two examples of such considerations which are conducive to good form and falsework movement design are:

1. Maintaining the size, alignment, and lengths of column forms for as many stories as possible.
2. Maintaining a flat spandrel beam condition to allow unrestricted horizontal movement of forms and falsework.

4.13. Columns

Multi-story exterior columns should be the same width for the entire height of the structure. The space between columns should be such that an opening can be made to accommodate standard sizes of sash or wall materials.

The cross-sectional dimensions of columns in multi-story buildings should remain constant for as many stories as possible. Where the required cross-sectional dimensions of a column may be decreased, the change should be made in one dimension only. The outside surface and the width of exterior columns should be kept constant, with the inside surface only being set back.

When using columns of circular cross-section, the diameter, and any changes in diameter, should be in even 2-inch [50-mm] increments. The diameter of interior columns should be as small as is consistent with the structural requirements, and as far as practicable, the diameters of all columns should be constant throughout a single story. The center-to-center spacing of columns should be uniform, if possible.

Column reinforcement should generally be of the largest sizes of reinforcing bars as practicable. According to standard industry practice, all vertical bars in square or rectangular columns will be shop offset bent at contact lap splices. The amount of offset for all bars is made the same as for the reinforcing bars located in the corners of the columns. Vertical bars in round columns where the size of the column is unchanged need not be offset bent

AVA Documents Document Sharing Hub
Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

at lap splices except when a maximum number is required above the location of the lap splice, making it impossible to lap splice the bars on the same circumference. When the column above is offset 3 inches [80 mm] or more, straight bars below should extend to within 3 inches [80 mm] of the top of slab and separate straight dowels used. The difficulty of determining a lap splice of two different size bars to develop the larger bar makes it desirable to reduce bar sizes when proceeding up a multi-storied column. Where possible, because of the lengths required for lap splices of the larger size bars, vertical bars should be permitted to extend two or more stories.

Only the recommended sizes of spirals shown in Appendix B, which are 3/8-inch dia or #3 [10-mm dia or #10], 1/2-inch dia or #4 [13-mm dia or #13], and 5/8-inch dia or #5 [16-mm dia or #16], should be specified by the Architect/Engineer. The diameter of column spirals is defined as the outside-to-outside measurement of the bar or wire, with a tolerance allowance of ±1/2 inch [± 15 mm] for diameters ≤ 30 inches [750 mm], and ±1 inch [± 25 mm] for larger diameters. The clear spacing between turns of any spiral should not exceed 3 inches [80 mm] nor be less than 1 inch [25 mm] and pitch is to vary by ¼-inch [5-mm] intervals.

Fabricating equipment limits minimum spiral out-to-out diameter as follows:

- 9 inches [225 mm] for 3/8 inch [10 mm] diameter or #3 [#10] spirals
- 12 inches [300 mm] for 1/2 inch [13 mm] diameter or #4 [#13] spirals
- 15 inches [375 mm] for 5/8 inch [16 mm] diameter or #5 [#16] spirals

Shipping and handling equipment limits the maximum length for fabricated spirals to 20 feet [6000 mm] although economical and practical considerations may dictate shorter lengths. Spirals may be lap spliced or spirals fabricated from reinforcing bars may be welded in the fabricating shop or at the job-site. See Appendix B for further information on standard spirals.

4.14. Structural Integrity

The ACI Building Code requirements for achieving structural integrity in cast-in-place reinforced concrete construction focus on the structural detailing of the reinforcement. Basically, prescribed amounts of longitudinal reinforcement must be continuous over the supports of the structural members or reinforcing bars that terminate at discontinuous ends of a structural member have to be anchored with standard end hooks.

Cast-in-place structural members/systems which are affected by these provisions:

4.14.1 Joists

At least one reinforcing bar in the bottom of the joist rib has to be continuous over the support or the bar must be spliced with a Class A tension lap splice to a bar in the adjacent spans. At discontinuous ends of joists, anchorage of at least one bottom bar must be provided with a standard end hook.

4.14.2 Beams

Beams are categorized as either "perimeter" beams or "non-perimeter" beams. A spandrel beam would be a perimeter beam.

In perimeter beams, at least one-sixth of the flexural tension reinforcement required to resist negative moment at the face of the supports, and one-quarter of the flexural tension reinforcement required to resist positive moment at midspan, have to be made continuous around the perimeter of the structure. Closed stirrups are also required in perimeter beams. It is not necessary to place closed stirrups within the beam-column joints. It is permissible to provide continuity of the top and bottom reinforcing bars by splicing the top bars at midspan and the bottom bars at or near the supports. Lap splicing with Class A tension splices is required.

For non-perimeter beams, the Architect/Engineer has two choices: (1) provide closed stirrups, or (2) make at least one-quarter of the flexural tension reinforcement required to resist positive moment at midspan continuous. Splicing the prescribed number of bottom bars over the supports with Class A tension lap splices is acceptable. At discontinuous ends of non-perimeter beams, the bottom bars must be anchored with standard end hooks.

4.14.3 Two-Way Slabs

In two-way slab construction, all bottom reinforcing bars within the column strip, in each direction, must be lap spliced with Class A tension lap splices. At least two of the bottom bars in the column strip must pass within the core of the columns and be anchored at exterior supports.

4.15. Splices

Lap Splices. For lap splice arrangements, the ACI 318 Building Code requires the Architect/Engineer to indicate the location (or limits thereof) and lengths of all lap splices on the project drawings or in the project specifications. Where reinforcing bars of two sizes are lap spliced in tension, industry practice is to use the larger of:

- The tension lap splice length for the smaller bar, or
- The tension development length for the larger bar.

When bars of different sizes are lap spliced in compression only, the lap splice length must be the larger of: the compression development length of the larger bar, or the compression lap splice length of the smaller bar.

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

Where the intent of the Architect/Engineer's design is to fully develop the larger bar by lap splicing it to a number of smaller bars, the splice arrangement should be dimensioned or specified completely.

Where partial to full tensile capacity is required with lapped splices, it is important that the Architect/Engineer specify and dimension the desired arrangement for staggering the splices.

Mechanical Splices. Where mechanical splices are required, the Architect/Engineer should indicate the acceptable types and any special end preparation required for the reinforcing bars.

Welded Splices. Where welded splices are used, the Architect/Engineer should require all welding to conform to the requirements of *Structural Welding Code—Reinforcing Steel* (ANSI/AWS D1.4).

For further information on splices and embedments of reinforcing bars, see *Reinforcement Anchorages and Splices*, available from the Concrete Reinforcing Steel Institute.

4.16. Designing with Coated Reinforcing Bars

The Architect/Engineer should realize that epoxy-coated and zinc-coated (galvanized) reinforcing bars undergo further processing as compared to uncoated bars. The coating process can increase the length of the normal delivery cycle. Replacement coated bars or additional coated bars to correct oversights may not be readily available. Thus, it is especially important that the Architect/Engineer furnish specific complete requirements on the project drawings or in the project specifications for the use of coated reinforcing bars.

To avoid confusion on construction projects where uncoated and coated reinforcing bars are used, the Architect/Engineer should be precise in identifying those bars on the project drawings which are to be coated. It is seldom sufficient to simply call for coated reinforcing bars in a structural member with a general note. Reinforcing bars projecting into a structural element should be identified if they are to be coated. For example, epoxy-coated reinforcing bars should be identified on project drawings with a suffix (E) and a note stating that all bars identified as such are to be epoxy-coated. A suffix (G) would be appropriate for identifying zinc-coated (galvanized) bars on project drawings.

No uncoated reinforcing steel, nor any other embedded metal dissimilar to zinc, should be permitted in close proximity to zinc-coated (galvanized) reinforcing bars except as part of a cathodic-protection system. Zinc-coated (galvanized) bars should not be coupled to uncoated bars.

4.17. Project Specifications Provisions for Coated Reinforcing Bars

The ASTM specifications A775/A775M and A934/934M for epoxy-coated reinforcing bars, and A767/A767M for zinc-coated (galvanized) reinforcing bars are patterned after the other ASTM standard specifications for steel reinforcement, i.e., the specifications for reinforcing bars, wire, welded wire fabric, and prestressing tendons are product or material standards. Their provisions cover the product or material to the point of shipment from the manufacturer's facility.

Thus, proper use of the ASTM A775/A775M, A934/A934M and A767/A767M product specifications requires the inclusion of provisions in the project specifications for:

1. Handling epoxy-coated reinforcing bars; require handling equipment to have padded contact areas; require multiple pick-up points for lifting bundles of coated bars to prevent bar-to-bar abrasion from sags in the bundles; and prohibit dropping or dragging coated bars.
2. Storage of epoxy-coated reinforcing bars at the jobsite, including provisions for protection of the coated bars for longer-term storage.
3. Repair of all damaged coating due to shipment, handling and placing operations; specify a limit on the maximum amount of repaired damaged areas.
4. Compatible bar supports, support bars, and spreader bars in walls.
5. Compatible tie wire.
6. Field bending of coated bars partially embedded in concrete; specify requirements for the repair of damaged coating after completion of field bending operations. Field bending of bars that are epoxy-coated in accordance with the ASTM A934/A934M specification is not recommended.
7. Mechanical splices; specify requirements for the repair of damaged coating after installation of mechanical splices; and if mechanical splices are not coated in the coating plant, specify requirements for coating all parts of mechanical splices including steel splice sleeves, bolts, and nuts.
8. Welded splices; specify any desired or more stringent requirements for preparation of the coated bars or for welding than those contained in the *Structural Welding Code—Reinforcing Steel* (ANSI/AWS D1.4); specify requirements for the repair of damaged coating after completion of welding; and specify requirements for coating all welds, and all steel splice members that are used to splice the bars.

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute

9. Cutting of coated reinforcing bars in the field; specify requirements for coating the ends of the bars.
10. Prohibit flame-cutting of epoxy-coated reinforcing bars.
11. When vibrators are used, require non-metallic heads to consolidate concrete around epoxy-coated reinforcing bars.

Minimum requirements for furnishing, fabricating, and placing reinforcing steel are presented in the "Suggested Specifications for Reinforcing Steel Including Provisions for Coated Reinforcement" in this chapter. See page 4-8. Provisions for epoxy-coated reinforcing bars, and zinc-coated (galvanized) reinforcing bars, and epoxy-coated welded wire fabric are included in the suggested specifications. The Institute's recommendations for bar supports for epoxy-coated reinforcing bars are given in Section 3.6 of Chapter 3.

Another resource available for the Architect/Engineer regarding project specifications is "Specifications for Structural Concrete (ACI 301)" — a reference specification published by the American Concrete Institute. The ACI 301 document is intended to be used in its entirety in the project specifications for any site-cast reinforced concrete construction project. Provisions for epoxy-coated reinforcing steel and zinc-coated (galvanized) reinforcing bars are included in the ACI 301 Specifications.

Since the purpose of coated reinforcing steel is to resist corrosion and prevent premature deterioration of reinforced concrete structures, it is imperative that all construction activities be performed with the objective of minimizing damage to the coating. When a construction project requires the use of coated reinforcing steel, the preconstruction meeting would be an ideal time to initiate the steps for maintaining the integrity and minimizing damage of the factory-produced coated reinforcing steel. Applicable provisions in the project specifications should be reviewed. The Owner's representative should clearly communicate the intent to enforce those provisions. All parties associated with the epoxy-coated reinforcing steel should participate in the meeting. Their roles and responsibilities should be established or clarified. Specific construction practices and inspection procedures should be reviewed. Anticipated delivery schedules and proposed storage sites at the construction project should also be outlined.

4.18. Fabrication of Reinforcing Bars

It is recommended that all reinforcing bars be shop fabricated, and so specified by the Architect/Engineer, as fabrication operations can be performed with greater accuracy in the fabricating shop.

1. Extra costs are incurred where applicable for size, grade, quantity, bending, special bending, special fabrication, detailing, and other services rendered by the Seller in accordance with Seller's current extra charges.
2. All bar bending should conform to the typical bar bends illustrated in Chapter 6, Figure 6-2, and the standard end hooks on page 6-5.

Dimensions of a bent reinforcing bar are the overall measurements, with ACI standard fabricating tolerances shown in Figures 7-3 and 7-4 of Chapter 7.

Unless otherwise specified on the project drawings or in the project specifications, bent reinforcing bars are furnished to ACI standard tolerances. Where closer tolerances are required, extra costs may be incurred.

4.19. Placing Drawings

As the term implies, "placing drawings" are used by Ironworkers at the job-site to place (install) the reinforcing steel within the formwork. In preparing the placing drawings for a specific structure, the Detailer determines the quantity of reinforcing bars, bar lengths, bend types, and bar positioning from the information and instructions provided on the project drawings and in the project specifications. While preparing the placing drawings, the Detailer also prepares bar lists. The Fabricator uses the bar lists to fabricate the reinforcing bars.

Placing drawings are prepared specifically for each individual structure. They are not produced from a general collection of drawings and sketches. Therefore, the project specifications should allow for an adequate time frame for the submission, correction, and approval of the placing drawings, as outlined in Section 6.3 of Chapter 6. Sometimes the Detailer, through an arrangement with the Architect/Engineer, will utilize electronic copies of the Architect/Engineer's drawings as a starting point when preparing the placing drawings. See Section 6.4.1 of Chapter 6 for further information.

Placing drawings are not design documents since they only convey the Architect/Engineer's intent. Thus, project specifications should not require that a Licensed Professional Engineer prepare or check and seal the placing drawings.

Documents
Document Sharing Hub

Full document details: CRSI Manual of Standard Practice (2003) | Concrete Reinforcing Steel Institute