WIRE REINFORCEMENT INSTITUTE®

MANUAL OF STANDARD PRACTICE

942 Main Street • Suite 300 • Hartford, CT 06103 (800) 552-4WRI [4974]

STRUCTURAL WELDED WIRE REINFORCEMENT

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WIRE REINFORCEMENT INSTITUTE, INC.

Excellence Set in Concrete©

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Manual of Standard Practice

Structural Welded Wire Reinforcement

Includes latest developments on use of WWR
under American Concrete Institute Building Code 318

Prepared under direction of the technical committees of the
Wire Reinforcement Institute, Incorporate

WIRE REINFORCEMENT INSTITUTE

WRI
942 Main Street, Suite 300
Hartford, CT 06103
Phone: (800) 522-4WRI [4974]
Fax: (860) 808-3009
www.wirereinforcementinstitute.org

Photo Captions for Front Cover Photos

1 – Jacking bars are used to properly position WWR after ready mix trucks leave and before screeding takes place.

2 – Properly positioning two layers of WWR on steel supports.

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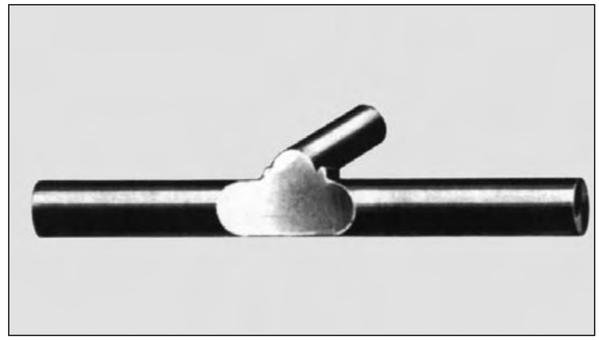
Welded wire reinforcement (WWR) is a prefabricated reinforcement consisting of parallel series of high-strength, cold-drawn or cold-rolled wire welded together in square or rectangular grids. Each wire intersection is electrically resistance-welded by a continuous automatic welder. Pressure and heat fuse the intersecting wires into a homogeneous section and fix all wires in their proper position. Plain wires, deformed wires or a combination of both may be used in WWR.

Welded plain wire reinforcement bonds to concrete by the positive mechanical anchorage at each welded wire intersection. Welded deformed wire utilizes deformations plus welded intersections for bond and anchorage.

Concrete structures are being successfully and economically reinforced with high-strength, uniformly distributed wires in WWR. The smaller diameter, closely-spaced wires of WWR provide more uniform stress distribution and more effective crack control in slabs and walls. The wide range of wire sizes and spacings available makes it possible to furnish the exact cross-sectional steel area required. The welded crosswires hold the reinforcement in the proper position, uniformly spaced. The ease and speed with which WWR can be handled and installed considerably reduces placing time, resulting in reduced cost.



Section at typical weld showing complete fusion of intersecting wires.

Reduced construction time is of particular benefit to the owner by affording earlier occupancy and reducing total (project) cost. Material savings can be realized by specifying WWR with higher yield strengths as recognized by ACI 318 and ASTM. Consult various manufacturers for their high-strength capabilities.

This manual provides WWR product information, material specifications, design and detailing requirements, and various tables and design aids for those interested in the design and construction of reinforced concrete structures.

Placing a shear cage of welded wire reinforcement in a concrete girder for a sports stadium.

2.1 Item Description

In the welded wire industry, an "item" is the term used to designate a complete unit of WWR as it appears on an order form.

2.2 Wire Size Designation

Individual wire (plain and deformed) size designations are based on the cross-sectional area of a given wire. Gage numbers were used exclusively for many years. The industry changed over to a letter-number combination in the 1970's. The prefixes "W" and "D" are used in combination with a number. The letter "W" designates a plain wire and the letter "D" denotes a deformed wire. The number following the letter gives the cross-sectional area in hundredths of a square inch. For instance, wire designation W4 would indicate a plain wire with a cross-sectional area of 0.04 sq. in.; a D10 wire would indicate a deformed wire with a cross-sectional area of 0.10 sq. in. The size of wires in welded wire mesh is designated in the same manner. This system has many advantages. Since the engineer knows the cross-sectional area of a wire and the spacing, the total cross-sectional area per foot of width can easily be determined. For instance, a W6 wire on 4 inch centers would provide 3 wires per foot with a total cross-sectional area of 0.18 sq. in. per foot of width.

When describing metric wire, the prefix "M" is added. MW describes metric plain wire and MD metric deformed wire. The wire spacings in metric WWR are given in millimeters (mm) and the cross-sectional areas of the wires in square millimeters (mm^2).

Nominal cross-sectional area of a deformed wire is determined from the weight (mass) per foot of wire rather than the diameter.

2.3 Style

Spacings and sizes of wires in WWR are identified by "style." A typical style designation is:

6 x 12–W12 x W5

This denotes a unit of WWR in which:

• Spacing of longitudinal wire	=	6" (152mm)
• Spacing of transverse wires	=	12" (305mm)
• Size of longitudinal wires	=	W12 (0.12 sq. in.) (77mm^2)
• Size of transverse wires	=	W5 (.05 sq. in.) (32mm^2)

Thus, the style for the sample above would be expressed metrically as 152 x 305–MW77 x MW32. A welded deformed wire style would be noted in the same manner by substituting the prefix D for the W. Note that "style" gives spacings and sizes of wires only and does not provide any other information such as width and length of sheet.

WWR with non-uniform wire spacings is available. In this case, special information is added to the style designation to describe the reinforcement.

It is very important to note that the terms longitudinal and transverse are related to the manufacturing process and do not refer to the relative position of the wires in a concrete structure. The WWR manufacturing process is discussed in detail in section 3.1. Transverse wires are individually welded at right angles as the reinforcement advances through the welder. In some WWR machines, the transverse wire is fed from a continuous coil; in others they are precut to length and hopper fed to the welding position.

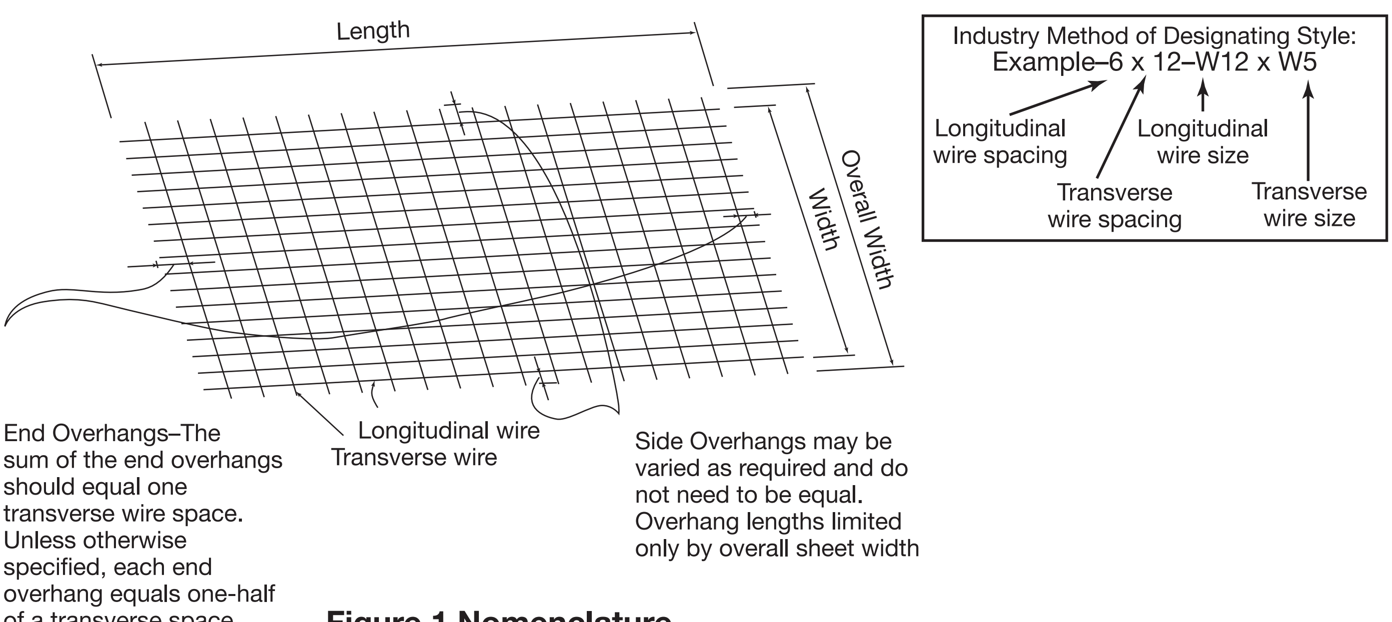


Figure 1 Nomenclature

2.4 Dimensions

Description of width, length and overhang dimensions of sheets follow:

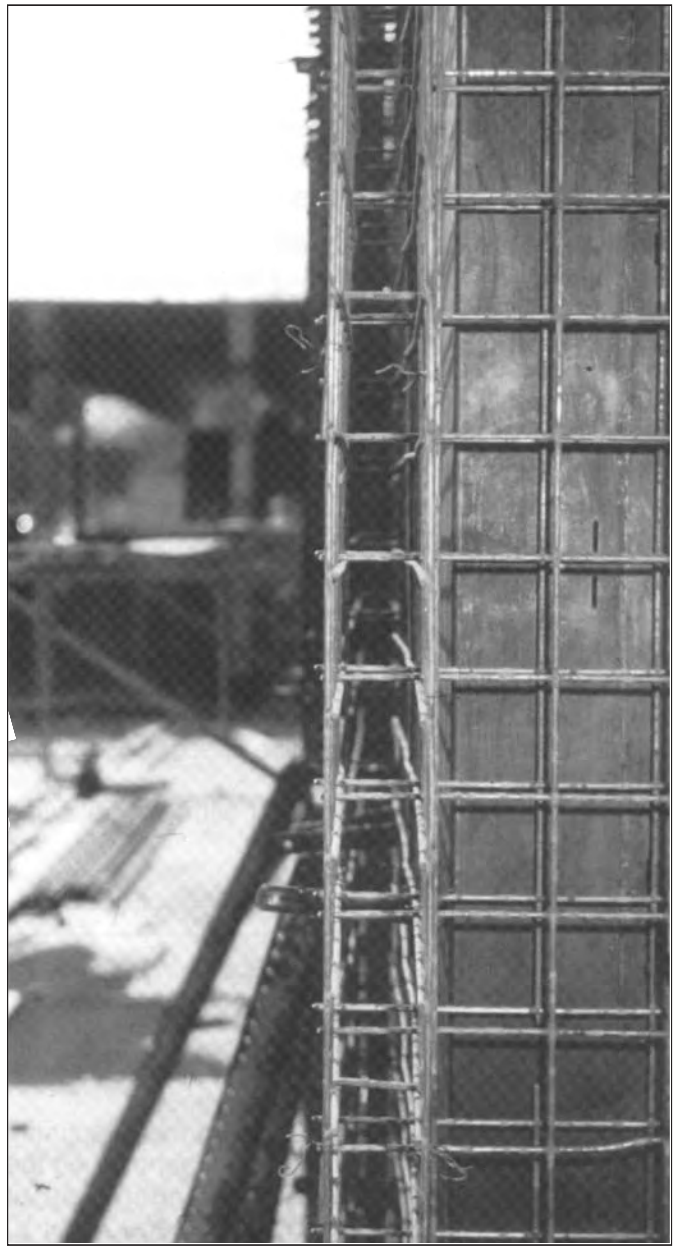
Width = Center to center distance between outside longitudinal wires. This dimension does not include overhangs.

Side Overhang = Extension of transverse wires beyond centerline of outside longitudinal wires. If no side overhang is specified, WWR will be furnished with overhangs on each side, of no greater than 1 inch (25 mm). Wires can be cut flush (no overhangs) specified thus: (+0", +0"). When specific overhangs are required, they are noted thus: (+1", +3") or (+6", +6").

Overall Width = Width including side overhangs, in. (or mm). In other words the tip-to-tip dimension of transverse wires.

Length = Tip-to-tip dimension of longitudinal wires. Whenever possible this dimension should be an even multiple of the transverse wire spacing. [The length dimension always includes end overhangs.]

End Overhangs = Extension of longitudinal wires beyond centerline of outside transverse wires. Unless otherwise noted, standard end overhangs are assumed to be required and end overhangs need not be specified. Non-standard end overhangs may be specified for special situations; preferably the sum of the two end overhangs should equal the transverse wire spacing.



(Above) Inner and outer vertical face of wall reinforcement.

The following example of welded wire reinforcement items illustrates how a typical order using the nomenclature described might appear:

Item	Quantity	Style	Width	Side Overhangs	Lengths
1	1000 Sheets	12 x 12–W11 x W11	90"	(+6", +6")	15'-0"
2	150 Sheets	6 x 6–W4 x W4	60"	(+0", +0")	20'-0"
3	500 Sheets	6 x 12–D10 x D6	96"	(+3", +3")	17'-0"

A sample metric order would appear as follows:

Item	Quantity	Style	Width	Side Overhangs	Lengths
1	1000 Sheets	305 x 305–MW71 x MW71	2286mm	(+152, +152)	4.6m
2	150 Sheets	152 x 152–MW26 x MW26	1524mm	(+0, +0)	6.1m
3	500 Sheets	152 x 305–MD65 x MD39	2438mm	(+76, +76)	5.2m

3.1 Manufacturing Process

The wire used in welded wire reinforcement is produced from controlled-quality, hot-rolled rods. These rods are cold-worked through a series of dies or cassettes to reduce the rod diameter to the specified diameter; this cold-working process, increases the yield strength of the wire. Chemical composition of the steel is carefully selected to give proper welding characteristics in addition to desired mechanical properties.

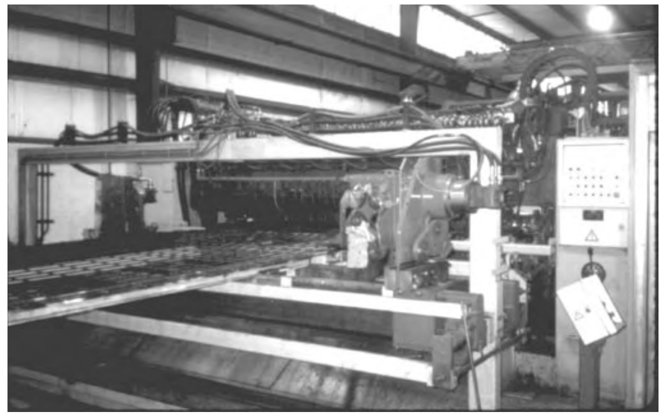
WWR is produced on automatic welding machines which are designed for long, continuous operation. Longitudinal wires are straightened and fed continuously through the machine. Transverse wires, entering from the side or from above the welder, are individually welded at right angles to the longitudinal wires each time the longitudinal wires advance through the machine a distance equal to one transverse wire spacing.

WWR is manufactured with the following variables:

1. Longitudinal wire spacing
2. Longitudinal wire size
3. Width
4. Side and end overhangs
5. Transverse wire size
6. Transverse wire spacing
7. Length

These variables may be changed during manufacturing with different amounts of time required depending on the type and extent of the change (or combination of changes). The above listing is in the general order of time involved, with the most time-consuming operation listed first. For example, a change in longitudinal wire spacings from one item to another requires the repositioning of all welding heads, wire straighteners and feed tubes while a change in length requires only an adjustment in the timing sequence of the shear which cuts the sheet to proper length.

For economy the more difficult machine changes require minimum quantities per item in order to offset the additional production time required. Consult manufacturers for stocked quantities or minimum quantities of special styles.



Latest WWR machinery can weld to 3/4” diameter wires.

WWR used in highway median barriers.

3.2 Minimum Quantity Requirements

The use of welded wire reinforcement becomes more efficient and economical as the amount of repetition in reinforcement increases. Economy is governed by the manufacturing process as described in Section 3.1 and by the industry practice of carrying certain common welded wire reinforcement items in stock or inventory.

The following two sections outline the minimum quantity requirements for stock (inventoried) items and non-standard items.

3.3 Common Sizes

Certain items of welded plain or deformed WWR are carried in stock by many WRI members either at the producing mills or warehousing points. While practice varies somewhat between manufacturers and localities, many of the items listed in Table 1 are usually available.

3.4 Individual Project Needs

Individual projects will require non-standard WWR sizes and styles in order to meet specific reinforcing needs. Minimum quantity requirements for non-standard orders vary by producer but the following guidelines for maximizing economy of orders can be used.

1. The most important factor affecting economy is to minimize the number of longitudinal wire spacings. An example is using wide spaced wires, but placing 1/2 size, closely spaced wires at edges, in the splice zones to obtain the required steel area per foot or meter.
2. The second most important factor is controlling the number of different wire sizes. Many welding machines have variable step spacing capabilities. This feature becomes necessary to manufacture sheets, which require variable spacings used to fabricate column tie and beam stirrup cages. One transverse size, therefore is used to obtain the required steel areas.

Common sheet sizes are:

	Customary in. ft.	Metric mm M
U.S. (except west coast)	96 x 12.5	2438 x 3.8
U.S. (west coast)	96 x 16	2438 x 4.6
	96 x 20	2438 x 6.1
	84 x 20	2134 x 6.1
	84 x 25	2134 x 7.6

	Customary in. ft.	Metric mm M
Canada	48 x 8	1219 x 2.4
	96 x 12	2438 x 3.7
	96 x 14	2438 x 4.3
	96 x 16	2438 x 4.9
	96 x 20	2438 x 6.1

TABLE 1 (Revised) **Common [3] Styles of Metric Welded Wire Reinforcement (WWR) With Equivalent US Customary Units**

	Equivalent US Customary Style	A (in^2/ft)	Wt (lbs/CSF)	A (mm^2/m)	Metric System (MW = Plain wire)[1]	Wt. (kg/m^2)
A[1&4]	4x4 – W1.4xW1.4	.042	31	88.9	102x102 – MW9xMW9	1.51
	4x4 – W2.0xW2.0	.060	44	127.0	102x102 – MW13xMW13	2.15
	4x4 – W2.9xW2.9	.087	62	184.2	102x102 – MW19xMW19	3.03
	4x4 – W4.0xW4.0	.120	88	254.0	102x102 – MW26xMW26	4.30
	6x6 – W1.4xW1.4	.028	21	59.3	152x152 – MW9xMW9	1.03
	6x6 – W2.0xW2.0	.040	30	84.7	152x152 – MW13xMW13	1.46
	6x6 – W2.9xW2.9	.058	42	122.8	152x152 – MW19xMW19	2.05
	6x6 – W4.0xW4.0	.080	58	169.4	152x152 – MW26xMW26	2.83
B[1]	4x4 – W3.1xW3.1	.093	65	196.9	102x102 – MW20xMW20	3.17
	6x6 – W4.7xW4.7	.094	68	199.0	152x152- MW30xMW30	3.32
	12x12 – W9.4xW9.4	.094	71	199.0	305x305 – MW61xMW61	3.47
	12x12 – W17.1xW17.1	.171	128	362.0	305x305 – MW110xMW110	6.25
C[1]	6x6 – W8.1xW8.1	.162	116	342.9	102x102 – MW52xMW52	5.66
	6x6 –W8.3xW8.3	.166	119	351.4	152x152 - MW54xMW54	5.81
	12x12 – W9.1xW9.1	.091	69	192.6	305x305 – MW59xMW59	8.25
	12x12 – W16.6xW16.6	.166	125	351.4	305x305 – MW107xMW107	9.72
D[1]	6x6 – W4.4xW4.4	.088	63	186.3	102x102 – MW28xMW28	3.22
	6x6 –W8xW8	.160	115	338.7	152x152 - MW52xMW52	5.61
	12x12 – W8.8xW8.8	.088	66	186.3	305x305 – MW57xMW75	3.22
	12x12 – W16xW16	.160	120	338.7	305x305 – MW103xMW103	5.61
E[1]	6x6 – W4.2xW4.2	.084	60	177.8	102x102 – MW27xMW27	3.08
	6x6 –W7.5xW7.5	.150	108	317.5	152x152 - MW48xMW48	5.52
	12x12 – W8.3xW8.3	.083	63	175.7	305x305 – MW54xMW54	3.08
	12x12 – W15xW15	.150	113	317.5	305x305 – MW97xMW97	5.52

1 Group A – Compares areas of WWR at a minimum f_y = 65,000 psi
Group B – Compares areas of WWR at a minimum f_y = 70,000 psi
Group C – Compares areas of WWR at a minimum f_y = 72,500 psi
Group D – Compares areas of WWR at a minimum f_y = 75,000 psi
Group E – Compares areas of WWR at a minimum f_y = 80,000 psi

2 Wires may also be deformed, use prefix MD or D, except where only MW or W is required by building codes (usually less than a .. MW26 or W4). Also wire sizes can be specified in 1 mm^2 (metric) or .001 in (US Customary) increments.

3 For other available styles or wire sizes, consult other WRI publications or discuss with WWR manufacturers.

4 Styles may be obtained in roll form. Note: It is recommended that rolls be flattened and cut to size before placement.

4.1 Specifications

The American Society for Testing and Materials (ASTM) has established specifications for plain and deformed wires as well as welded plain and deformed wire reinforcement. The Canadian Standards are withdrawn (CSA) and replaced with applicable ASTM standards for use in Canada. Table 2. Some governmental agencies have special specifications which will control.

4.2 WWR Coatings

There are two types of coatings used on welded wire reinforcement. One is galvanized, usually applied to the cold-drawn wire before it is welded into reinforcement. The hot-dipped galvanizing process is similar to that specified in ASTM A641. The other types of coating are epoxy. The application of the epoxy coating occurs after the sheets have been welded. The requirements for epoxy-coated welded wire reinforcement are provided in ASTM A884.

TABLE 2

Specifications Covering Welded Wire Reinforcement

U.S. and CANADIAN SPECIFICATION	TITLE
ASTM A 82	Cold-Drawn Plain Steel Wire for Concrete Reinforcement
ASTM A 185	Welded Plain Steel Wire Reinforcement for Concrete Reinforcement
ASTM A 496	Deformed Steel Wire for Concrete Reinforcement
ASTM A 497	Welded Deformed Steel Wire Reinforcement for Concrete Reinforcement

4.3 Yield Strength

The yield strength values shown in Table 3 are ASTM requirements for minimum yield strength measured at a strain of .005 in/in. The ACI 318 Building Code, Sections 3.5.3.4, 3.5.3.5 and 3.5.3.6, state that yield strength values greater than 60,000 psi (420 MPa) may be used, provided they are measured at a strain of .0035 in/in (mm/mm). Higher yield strength welded wire WWR is available and can be specified in accordance with ACI code requirements.

Elongation test criteria on maximum strength (or maximum stretch) is shown in tables 3(b) and 3(c). Maximum stretch can be defined as total elongation which is a test in A370, A4.4.2, measuring both the elastic & plastic extension.

The testing done here and recorded in the Tables 3(b) & 3(c) correlate with other testing/research done by some major universities. They have found that high strength WWR is capable of developing significant strains and exhibits sufficient ductility to redistribute the strains to avoid brittle shear failure.

4.4 Weld Shear Strength

The values shown in Table 3 are the ASTM requirements for weld shear strength which contribute to the bond and anchorage of the wire reinforcement in concrete.

A maximum size differential of wires being welded together is maintained to assure adequate weld shear strength. For both plain and deformed wires, the smaller wire must have an area of 40 percent or more of the steel area of the larger wire.

Larger Wire Size	Smaller Wire Size
W20 (MW 129)	W8 (MW 52)
W15 (MW 97)	W6 (MW 39)
D20 (MD 129)	D8 (MD 52)

TABLE 3(a) Minimum Requirements of Steel Wires in Welded Wire Reinforcement

WELDED PLAIN WIRE REINFORCEMENT ASTM A185, CSA G30.5

Wire Size	Tensile Strength psi	Yield Strength psi	Weld Shear Strength
W1.2 & over	75,000 (520 MPa)	65,000 (450 MPa)	35,000 (240 MPa)
under W1.2	70,000 (480 MPa)	56,000 (390 MPa)	–

WELDED DEFORMED WIRE REINFORCEMENT ASTM A497, CSA G30.15

Wire Size	Tensile Strength psi	Yield Strength psi	Weld Shear Strength
D 45 thru D 4	80,000 (550 MPa)	70,000 (480 MPa)	35,000 (240 MPa)
under D 4	80,000 (550 MPa)	70,000 (480 MPa)	–

TABLE 3(b) Test of Elongation (total - Elastic & Plastic) for various Wire Sizes

Gauge Length	Wire Size	Elongation Mean (%)	Elongation Std. Dev.	f_y @ 0.35% Strain (ksi)	f_t Ultimate Tensile @ Fracture (ksi)
4”	W3	7.2	1.1	87	100
	W4	10.5	1.59	80	91
6”	W3.5	7.9	0.05		
	W6.5	8.6	0.90	84	100
	W10	7.4	0.74	80	92
7”	W5.5	7.3	0.67	78	96
	W6	8.7	0.67	83	98
	W8	8.9	0.05	73	87
	D12	13.4	0.49	88	98

TABLE 3(c) Summary of test Criteria in table 3(b) (27 Samples Tested)

f_y Range @ 0.35% of Strain	f_t Range (ult)	%Elongation total* A370, A4.4.2	%Elongation Permanent A370, A4.4.1
73-88ksi	91-102 ksi	6-14%	4-6%
		Mean - 8.9%	5%

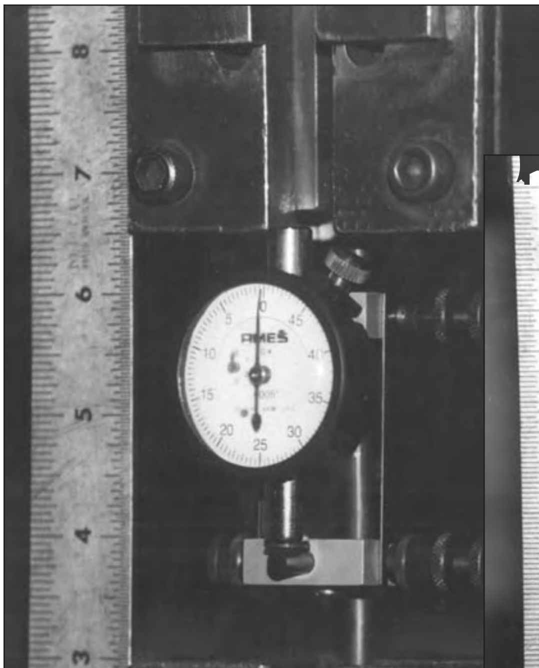
* Maximum strength or maximum stretch is the full measure of extension before fracture. It is the true measure of elongation (total). Research background for this testing can be found in the ACI discussion paper, Disc.88-S60 in ACI Structural Journal, July - August 1992.

Note 1

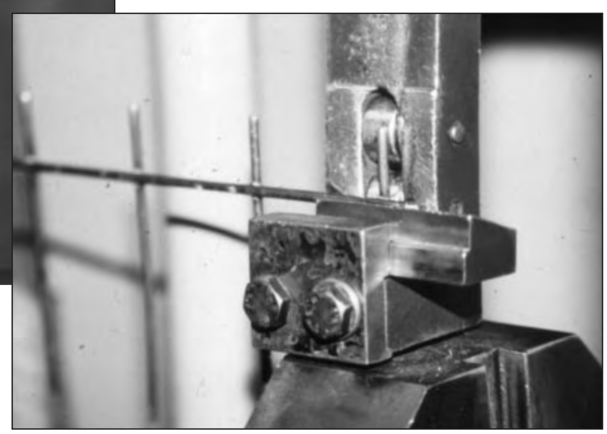
3 samples of each size were tested from the same heat of steel rod
7” was the max. gauge length for the testing machine used.
Rod (f_t) is 55 - 60 ksi
Rod type is 1006 - 1008 carbon steel.
Rate of speed for loading samples was a min. of 10,000 psi / minute in accordance with A370, 7.4.3

Note 2

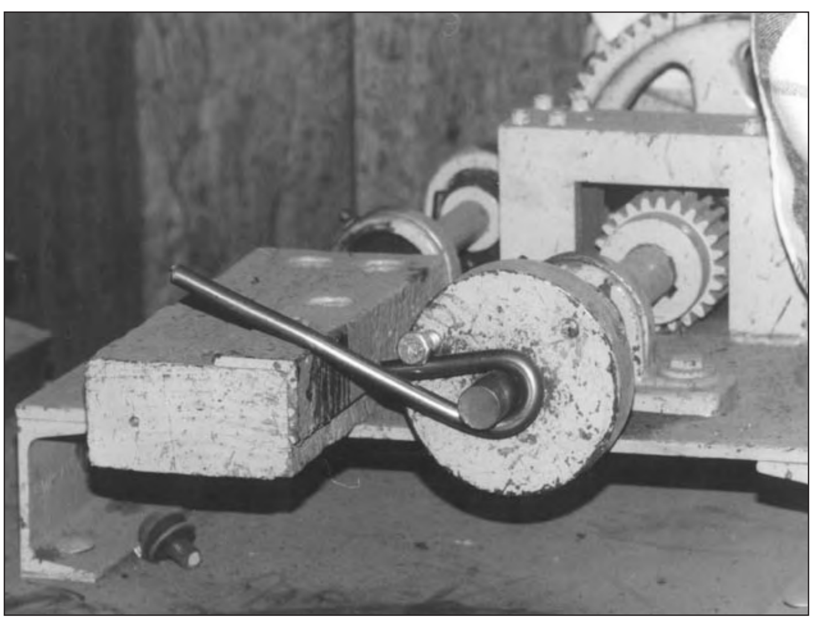
Recent testing of strain at ultimate strength provided the following data. 7 samples tested - wire sizes tested - W2.9, D8, D15. Range of ultimate or tensile strength results at 0.0050 in/in - 82.5 - 103ksi. Range of ultimate or tensile strength results at 0.0035 in/in - 77.5 - 93ksi. Range of strain results at ultimate strength were 0.0075 - 0.0090 in/in, which shows that strain of both wire and welded wire at ultimate strengths are 2 - 2.5 times the ACI 318 requirement of strain to be 0.0035 in/in at minimum yield strengths. This research shows there is a substantial safety factor for wire and welded wire reinforcement. (Charts and graphs are available on request)



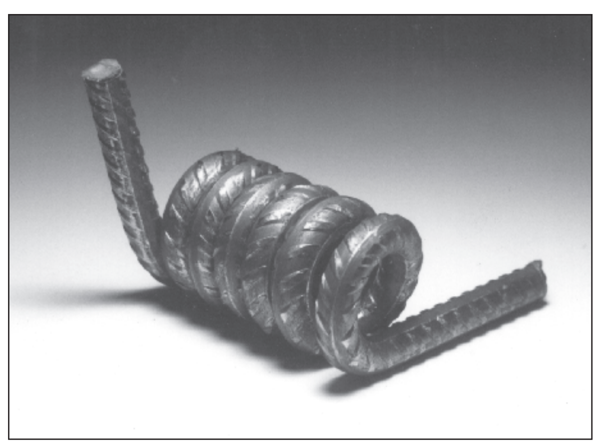
External Measuring of Elongation



Weld Shear Testing



Wrap Testing

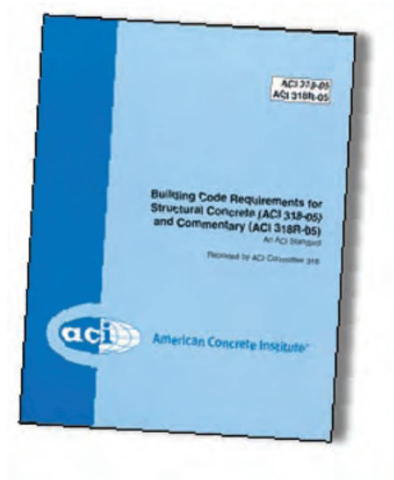


PARTIAL NOTATION

TERMS USED IN BUILDING CODE REQUIREMENTS
FOR REINFORCED CONCRETE (ACI 318)

A	=	effective tension area of concrete surrounding the main tension reinforcing bars and having the same centroid as that reinforcement, divided by the number of bars, sq. in. (mm^2)
A_s	=	area of nonprestressed tension reinforcement, sq. in. / 1ft. (mm^2 / m)
A_b	=	area of individual wire to be developed or spliced, sq. in. (mm^2)
c	=	spacing or cover dimension, in. (mm)
d	=	distance from extreme compression fiber to centroid of tension reinforcement, in (mm)
d_b	=	nominal diameter of bar, wire, or prestressing strand, in. (mm)
d_c	=	thickness of concrete cover measured from the extreme tension fiber to the center of the bar located closest thereto, in. (mm)
$f'c$	=	specified compressive strength of concrete, psi. (MPa)
$\sqrt{f'c}$	=	square root of specified compressive strength of concrete, psi. (MPa)
f_s	=	calculated stress in reinforcement at service loads, psi. (MPa)
f_y	=	specified yield strength of nonprestressed reinforcement, psi. (MPa)
h	=	overall thickness of member, in. (mm)
K_{tr}	=	transverse reinforcement index, see 12.2.3, Chapter 12
ℓ_d	=	development length, in. (mm)
ℓ_{db}	=	basic development length, in. (mm)
S_{tr}	=	spacing of wires to be developed or spliced, in. (mm)
z	=	a quantity limiting distribution of flexural reinforcement
α	=	reinforcement location factor, horizontal reinforcement 12” of fresh concrete below d_b
ψ_t	=	coating factor
ψ_e	=	lightweight factor
ψ_s	=	reinforcement size factor

Appropriate code provisions concerning features and use of welded wire reinforcement are paraphrased and summarized in the following outline form to identify areas of the code which specifically apply to welded wire reinforcement.



ACI 318 Code Provisions

A. Definitions and Specifications
B. Bond and Development
C. Splices
D. Spacing of Wires
E. Minimum Reinforcing Requirements
F. Bends and Hooks
G. Lateral Reinforcement (Stirrups and Ties)
H. Design Methods and Details

PROVISION	ACI 318-05 SECTION NUMBER
A. Definitions and Specifications	
1. Welded wire reinforcement (plain and deformed) is defined as deformed reinforcement when conforming to subsequent sections	2.2
2. Deformed wire conforms to ASTM A496. Minimum yield strength (fy) is considered to be 60,000 psi (420 MPa) unless measured at 0.35 percent strain........	3.5.3.4
3. Deformed wire reinforcement conforms to ASTM A497. Maximum spacing of welded intersections in direction of principal reinforcement = 16 inches (400mm), except where wire fabric is used as stirrups (12.13.2)	3.5.3.6
4. Spiral reinforcement plain wire conforms to ASTM A82. Minimum yield strength (fy) is considered to be 60,000 psi (420 MPa) unless measured at 0.35 percent strain	3.5.4.2
5. Epoxy coated wires and welded wire reinforcement shall comply with ASTM A 884	3.5.3.8
6. Welded plain wire reinforcement conforms to ASTM A185. Minimum yield strength for ASTM A82 wire is considered to be 60,000 psi unless measured at 0.35% strain. Maximum spacing of welded intersections in direction of principal reinforcement = 12 inches (300 mm)	3.5.3.5

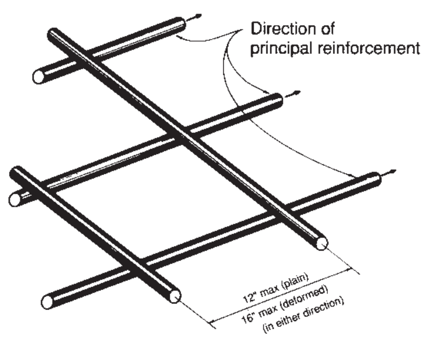
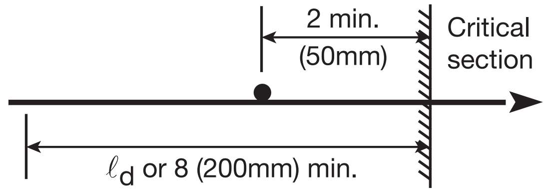


Figure 3 Direction of Principal Reinforcement

PROVISION	ACI 318-05 SECTION NUMBER

B. Bond and Development

Welded intersections of welded wire reinforcement bond to concrete by mechanical anchorage. See Section 12.7 & 12.8 for bond and development of welded wire reinforcement. 12.7 12.8 R12.7



Deformed wire reinforcement:

The development length (ℓ_d) in inches of diameter d_b for deformed wire in tension shall be determined from equation 12.2.3, ℓ_d/d_b shall be: 12.2.1

$$\ell_d = \left(\frac{3}{40} \frac{f_y}{\sqrt{f'_c}} \frac{\psi_t \psi_e \psi_s \lambda}{\left(\frac{c_b + K_{tr}}{d_b} \right)} \right) d_b \; *$$ 12.2.3

in which the term $(c+K_{tr})/d_b$ shall not be greater than 2.5.

ℓ_d of welded deformed wire shall not be less than 12". 12.2.3

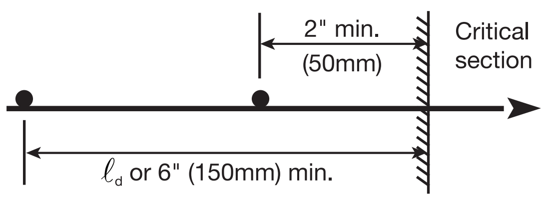
For design simplication, $K_{tr} = 0$ 12.2.4

The development length ℓ_d of welded deformed wire measured from the point of critical section to the end of wire shall be computed as the product of the development length from 12.2.2 or 12.2.3 times a welded wire factor from 12.7.2 or 12.7.3. It shall be permitted to reduce the development length in accordance with 12.2.5 (excess reinforcement) when applicable, but ℓ_d shall not be less than 8 in. when using the welded wire factor in 12.7.2.. It shall be permitted to use an epoxy-coating factor β of 1.0 in. 12.2.2 and 12.2.3. 12.7.1

The welded wire factor is: $\left(\frac{f_y - 35{,}000}{f_y} \right)$ or $\left(\frac{5d_b}{S} \right)$ but not greater than 1.** 12.7.2

Figure 4. Deformed Wire and Welded Deformed Wire Reinforcement Development Lengths

12.7.3 12.7.4



The development length ℓ_d of welded plain wire measured from the point of critical section to the outermost cross wire shall not be less than:

$$\ell_d = 0.27 \; \frac{A_b}{S} \left(\frac{f_y}{\sqrt{f'_c}} \right) \lambda \; ***$$ 12.8

except that when reinforcement provided is in excess of that required, this length may be reduced in accordance with 12.2.5. ℓ_d shall not be less than 6 in. (150 mm).

Figure 5 Welded Plain Wire Reinforcement Development Length

* metric formula

$$\ell_d = \left(\frac{9}{10} \cdot \frac{f_y}{\sqrt{f'_c}} \cdot \frac{\psi_t \psi_e \psi_s \lambda}{\left(\frac{c+K_{tr}}{d_b} \right)^{*}} \right) d_b$$

**metric formula

$$\left(\frac{f_y - 240}{f_y} \right) \text{ or } \left(\frac{5d_b}{S_w} \right)$$

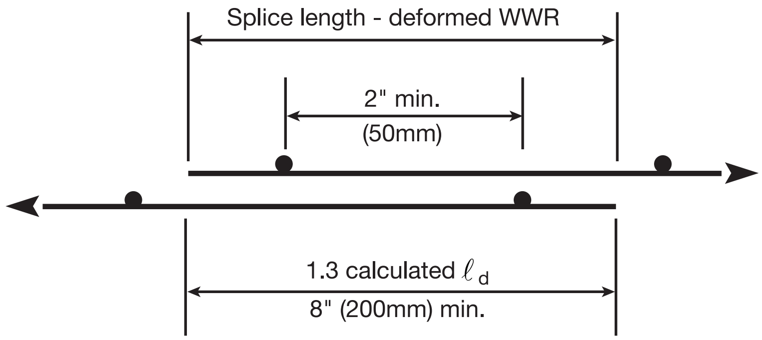
***metric formula

$$3.3 \; \frac{A_b}{S} \frac{f_y}{\sqrt{f'_c}} \; \lambda$$

PROVISION	ACI 318-05 SECTION NUMBER

C. Splices

The splice length in inches shall be the largest of the values shown in figure below.



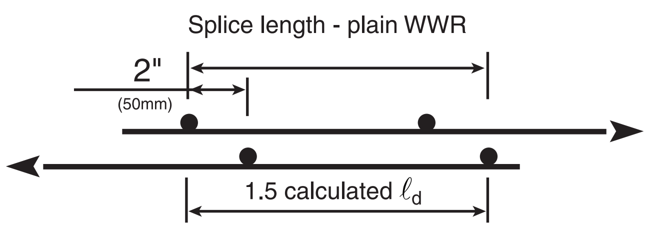
12.18.1

Table 5 gives typical splice and development lengths for welded deformed wire reinforcement. Note: Overhangs are part of the splice length.

Figure 6 Deformed Wire Reinforcement Splice Lengths

The splice length in inches shall be the largest of the values shown in the figures below.

(a) Splice when $\dfrac{A_s \text{ Provided}}{A_s \text{ Required}} < 2$ — 12.19.1



but not less than 1 space + 2” (50mm) nor 6” (150mm) minimum
Note: overhangs must be added to the splice length for welded plain wire reinforcement.

(b) Splice when $\dfrac{A_s \text{ Provided}}{A_s \text{ Required}} \geq 2$ — 12.19.2

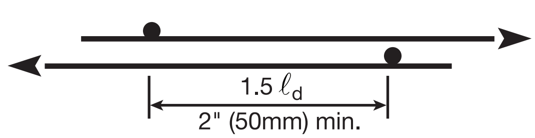


Table 6 gives typical splice and development lengths for welded plain wire reinforcement.

Figure 7 Plain Wire Reinforcement Splice Lengths

PROVISION	ACI 318-05 SECTION NUMBER
D. Spacing of Wires	
1. Maximum spacings in direction of calculated stress from Part 2, Chapter 3, “Materials”:	
Plain WWR 12” (305mm)...	3.5.3.5
Deformed WWR 16” (400mm)...	3.5.3.6
Note: Use above spacings except for welded wire used as stirrups	12.13.2
For single leg stirrups see 12.13.2.4	12.13.2.4
2. In walls and slabs other than concrete joist construction, the principal reinforcement shall not be spaced farther apart than 3 times the wall or slab thickness, nor more than 18 inches (500mm)	7.6.5
3. The spacing of reinforcement closest to tension face, s, shall not exceed that given by given by $$s = 15\left(\frac{40,000}{f_s}\right) - 2.5c_c \quad (10\text{-}4)$$ but not greater than **12(40,000/f_s)**, where c_c is the least distance from the surfaceor reinforcement or prestressing steel to the tension face. If there is only one bar or wire nearest to the extreme tension face, ***s*** used in Eq. (10-4) is the width of the extreme tension face.	
Calculated stress f_s in reinforcement closest to the tension face at service load shall be computed based on the unfactored moment. It shall be permitted to take f_s as **2/3f_y**	10.6.4
4. In slabs where principal reinforcement extends in one direction only, shrinkage and temperature reinforcement at right angles to the principal reinforcement shall be spaced not farther apart than 5 times the slab thickness, nor more than 18 inches (500mm)	7.12.2.2
5. Special provisions for walls require the following maximum spacing limitations:	
Vertical = 3 times wall thickness or 18 inches (500mm)..................	14.3.5
Horizontal = 3 times wall thickness or 18 inches (500mm)..................	14.3.5
6. Spacing reinforcement at critical sections shall not exceed two times the slab thickness, except in areas of cellular or ribbed construction. ACI Section 7.12 governs areas of cellular or ribbed construction in these slabs..	13.3.2
7. See page 15 for wire spacing requirements where welded wire reinforcement is used as shear reinforcement.	

PROVISION	ACI 318-05 SECTION NUMBER
E. Minimum Reinforcing Requirements	
For shrinkage and temperature reinforcement in structurally reinforced slabs*:	
1. Slabs where welded wire reinforcement with f_y = 65,000 psi (450 MPa);	R3.5.3.5
(ACI 318 assigns f_y = 60,000 psi (420 MPa) but makes provision for the use of higher f_y provided the stress corresponds to a strain of 0.35%). Use ratio of reinforcement-to-gross concrete area of 0.0018.	7.12.2.1 (b)
2. Slabs where welded wire reinforcement exceeds 65,000 psi (450 MPa), use $0.0018 \frac{60{,}000}{f_y}$, when f_y exceeds 60,000 psi (420 MPa), material shall be measured at a yield strain of .35%, but not less than 0.0014.	7.12.2.1 (c)
3. For two-way slab systems, the area of reinforcement in each direction shall be determined from moments at critical sections but shall not be less than that required by section 7.12.	13.3.1
For minimum wall reinforcement:	
1. Wall designs require the following minimum reinforcement ratios when reinforced with welded wire reinforcement (wire sizes not larger than W31 or D31) (MW200 or MD200).	14.3
Vertical - 0.0012..	14.3.2
Horizontal - 0.0020..	14.3.3
WRI Note – WWR Industry Capability is to W45 or D45 wire sizes.	
2. Special Provisions for Seismic Design The minimum reinforcement radio,ρ_v, for structural walls: Longitudinal and Transverse - 0.0025...	21.7.2.1
At least two curtains of reinforcement shall be used in a wall if the in-plane factored shear force assigned to the wall exceeds $2A_{cv}\sqrt{f'_c}$ (spacing each way shall not exceed 18 inches)....................................	21.7.2.2
For shear reinforcement:	
1. Shear reinforcement may consist of welded wire reinforcement with wires located perpendicular to axis of member.	11.5.1(b)
2. The values of f_y and f_{yt} used in design of shear reinforcement shall not exceed 60,000 psi, except the value shall not exceed 80,000 psi for welded deformed reinforcement	11.5.2
3. Minimum shear reinforcement area provision	11.5.6.1
* The following are minimum requirements for reinforced slabs on grade only:	
1. ACI 318 does not specify minimum reinforcing for slabs on grade.	
2. Refer to WRI, PCA, CRSI and ACI 360 technical publications for subgrade drag theory or requirements for structural slabs on grade.	
3. Refer to Section C of this publication, figures 6 and 7 for a reference to minimum splice lengths.	

PROVISION	ACI 318-05 SECTION NUMBER
F. Bends and Hooks	
1. Inside diameter of bends in welded wire reinforcement, plain or deformed, for stirrup and ties shall not be less than $4d_b$ for deformed wire larger than D6 (MD39) and $2d_b$ for all other wires. Bends with inside diameters of less than $8d_b$ shall not be less than $4d_b$ from the nearest welded intersection.	7.2.3
G. Lateral Reinforcement	
1. Equivalent areas of welded wire reinforcement may be used to furnish the tie or stirrup lateral reinforcement requirements.	7.11.3
2. The design yield strength of shear friction and torsion reinforcement shall not exceed 60,000 psi (420 MPa).	11.6.3.4 and 11.7.6
2 (a) Design yield strength of shear reinforcement shall not exceed 60,000 psi (420MPa) except that the yield strength of deformed WWR shall not exceed 80,000 psi (550 MPa)	11.5.2
3. Shear reinforcement may consist of welded wire reinforcement with wires located perpendicular to the axis of the member. The wires shall not be spaced further apart than d/2 in nonprestressed concrete and (3/4) h in prestressed concrete, but not more than 24 in. (600mm)..	11.5.1.1 and 11.5.1.1. (b) 11.5.4
4. Anchorage of web reinforcement: Ends of single leg, simple "U", or multiple "U" stirrups shall be anchored by one of the following means:	12.13.2.3
(a) Two longitudinal wires spaced at a 2 inch (50mm) spacing along the member at the top of the "U" or the top and bottom of a single leg.	12.13.2.3(a)
(b) One longitudinal wire not more than d/4 from the compression face and a second wire closer to the compression face and spaced at least 2 inches (50mm) from the first. The second wire may be located on the stirrup leg beyond a bend or on a bend with an inside diameter of at least $8d_b$.	12.13.2.3(b)
5. For each end of a single leg stirrup of welded plain or deformed wire, two longitudinal wires at a minimum spacing of 2 in. and with the inner wire at least the greater of d/4 or 2 in. from middepth of member d/2. Outer longitudinal wire at tension face shall not be farther from the face than the portion of primary flexural reinforcement closest to the face......	12.13.2.4
6. Ties for horizontal shear shall consist of welded wire reinforcement for vertical legs. All ties shall be fully anchored into interconnected elements in accordance with 12.13	17.6.2 and 17.6.3

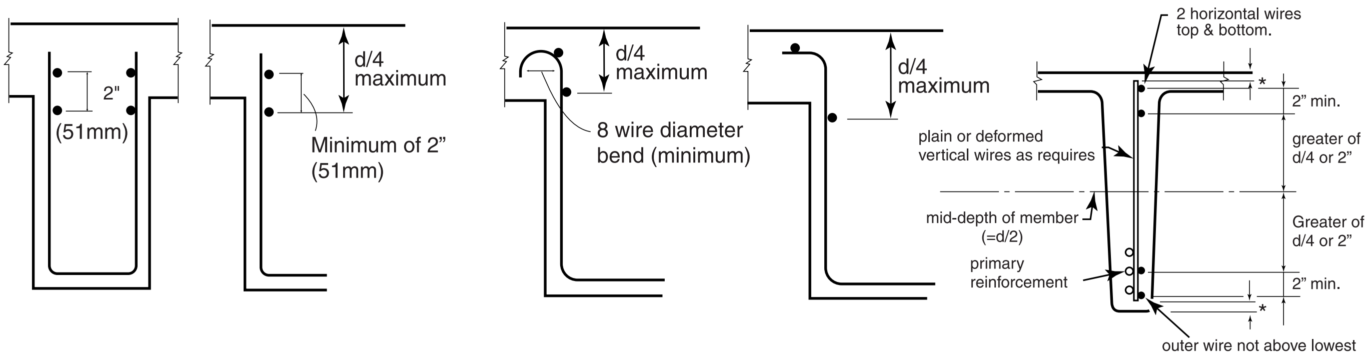


Figure 8 Anchorage of Web Reinforcement

***See Section 12.13.1**
(cover of reinforcement)

PROVISION	ACI 318-05 SECTION NUMBER
H. Design Methods and Details	
1. Draped Reinforcement: When welded wire reinforcement with wire size of W5 or D5 (MW32 or MD32) diameter or less is used for slab reinforcement in slabs not exceeding 10 feet (3m) in span, the reinforcement may be curved from a point near the top of the slab over the support to a point near the bottom of the slab at midspan, provided such reinforcement is either continuous over, or securely anchored at the support......................................	7.5.3
A WRI Note ***The W or D5 wire size is the maximum size of WWR to form a sinusoidal curve or warp the reinforcing at the points of contraflexure in a continuous slab design. When designs call for separate flat sheets of welded wire to satisfy positive and negative moment regions, larger wire sizes (up to W or D45) can be specified.***	
2. Designs shall not be based on a yield strength (f_y) in excess of 80,000 psi (550 MPa), except for prestressing tendons......................................	9.4
3. Welded wire reinforcement ASTM yield strengths are specified at 0.50 percent strain. ACI specifies use of maximum design yield strengths of 60,000 psi (420 MPa) unless f_y is measured at 0.35 percent strain..	3.5.3.4 3.5.3.5 3.5.3.6
4. Nonprestressed members may be designed using service loads (without load factors) and permissible service load stresses according to the following:	3.5.4.2
I. Deformed Wire Development and Splice Lengths	
1. Development length ℓ_d for deformed wire with no embedded cross wires is given by equations in 12.2.2 and 12.2.3	12.2.2 and 12.2.3
ℓ_d = ≤ 12" (305mm)	
Development length ℓ_d can be multiplied by applicable factors in 12.2.4, and 12.2.5	12.3.1 12.3.3
2. Tension splice lengths for deformed wire with no overlapped cross wires are given by the larger of (Class A splice = 1.0 ℓ_d or (Class B splice = 1.3 ℓ_d) but not less than 12 inches	12.15.1 and 12.15.2
A WRI Note ***ACI 318 does not cover splices for slabs on ground. WRI believes and many engineers agree that the strength of the reinforcing in most slabs on ground is not utilized to the full yield strength. Most slabs on ground utilize less than 50% of the yield strength of the reinforcement. Therefore, splices need only to be sufficient to secure the sheets of WWR together. The minimum splice is 2" plus overhangs. If the engineer believes the full strength of the reinforcing will be required then the splice equations in Chapter 12 apply.***	

PROVISION	ACI 318-05 SECTION NUMBER
J. Splice Lengths for Deformed Wire	12.2.1

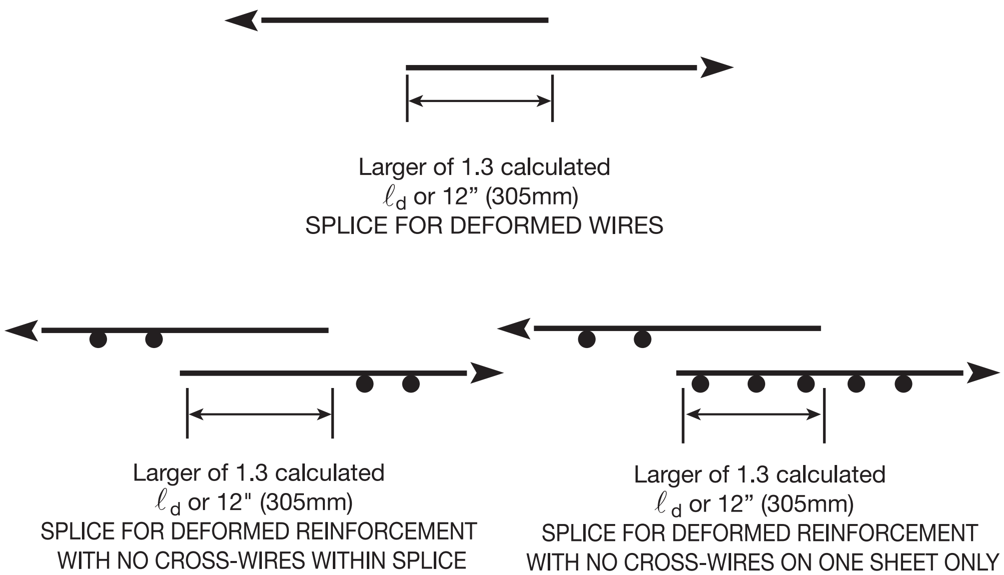


Figure 10 Deformed Wire Splices

TABLE 4♦ Typical Development & Splice Lengths, Deformed Wire

f_y = 70,000 psi, f'_c = 4,000 psi

customary units

Wire Size	* Development Length, in.	** Splice Length, in.
Aw	ℓ_d	**1.3** ℓ_d
D4	12	12
D5	12	12
D6	12	12
D7	12	12
D8	12	12
D9	12	12
D10	12	12
D12	12	14
D14	13	16
D16	14	18
D18	16	20
D20	17	22
D31	25	32
D45	34	44

TABLE 4M♦ Typical Development & Splice Lengths, Deformed Wire

f_y = 485 MPa f'_c = 28 MPa

metric units

Wire Size	* Development Length, mm.	** Splice Length, mm.
Aw	ℓ_d	**1.3** ℓ_d
MD 26	305	305
MD 32	305	305
MD 39	305	305
MD 45	305	305
MD 52	305	305
MD 59	305	305
MD 65	305	305
MD 77	305	356
MD 90	330	406
MD 103	356	457
MD 116	406	508
MD 129	432	559
MD 200	635	813
MD 290	864	1,118

* Sections 12.2.3, 12.2.4 and 12.2.5 must be used when applicable.

♦ Assumed 3/4” concrete cover.

** Splice length determined using calculated ℓ_d.

♦ Assumed 20mm concrete cover.

Sectional Areas of Welded Wire Reinforcement

TABLE 5 Customary Units

Wire Size Number		Nominal Diameter	Nominal Weight	As - Square Inch Per Linear Feet *Center to Center Spacing*								
Plain	*Deformed*	*Inches*	*Lbs./Lin. Ft.*	2”	3”	4”	6”	8”	10”	12”	16”	18”
W45	D45	0.757	1.530	2.70	1.80	1.35	.909	.68	.54	.45	.34	.30
W31	D31	0.628	1.054	1.86	1.24	.93	.62	.47	.37	.31	.23	.21
W20	D20	0.505	.680	1.20	.80	.60	.40	.30	.24	.20	.15	.13
W18	D18	0.479	.612	1.08	.72	.54	.36	.27	.216	.18	.14	.12
W16	D16	0.451	.544	.96	.64	.48	.32	.24	.192	.16	.12	.11
W14	D14	0.422	.476	.84	.56	.42	.28	.21	.168	.14	.11	.09
W12	D12	0.391	.408	.72	.48	.36	.24	.18	.144	.12	.09	.08
W11	D11	0.374	.374	.66	.44	.33	.22	.165	.132	.11	.08	.07
W10.5		0.366	.357	.63	.42	.315	.21	.157	.126	.105	.08	.07
W10	D10	0.357	.340	.60	.40	.30	.20	.15	.12	.10	.08	.07
W9.5		0.348	.323	.57	.38	.285	.19	.142	.114	.095	.07	.06
W9	D9	0.338	.306	.54	.36	.27	.18	.135	.108	.09	.07	.06
W8.5		0.329	.289	.51	.34	.255	.17	.127	.102	.085	.06	.06
W8	D8	0.319	.272	.48	.32	.24	.16	.12	.096	.08	.06	.05
W7.5		0.309	.255	.45	.30	.225	.15	.112	.09	.075	.056	.05
W7	D7	0.299	.238	.42	.28	.21	.14	.105	.084	.07	.053	.047
W6.5		0.288	.221	.39	.26	.195	.13	.097	.078	.065	.048	.043
W6	D6	0.276	.204	.36	.24	.18	.12	.09	.072	.06	.045	.04
W5.5		0.265	.187	.33	.22	.165	.11	.082	.066	.055	.041	.037
W5	D5	0.252	.170	.30	.20	.15	.10	.075	.06	.05	.038	.033
W4.5		0.239	.153	.27	.18	.135	.09	.067	.054	.045	.034	.03
W4	D4	0.226	.136	.24	.16	.12	.08	.06	.048	.04	.03	.027
W3.5		0.211	.119	.21	.14	.105	.07	.052	.042	.035	.026	.023
W3		0.195	.102	.18	.12	.09	.06	.045	.036	.03	.023	.02
W2.9		0.192	.098	.174	.116	.087	.058	.043	.035	.029	.022	.019
W2.5		0.178	.085	.15	.10	.075	.05	.037	.03	.025	.019	.017
W2.1		0.161	.070	.13	.084	.063	.042	.032	.025	.021	.016	.014
W2		0.160	.068	.12	.08	.06	.04	.03	.024	.02	.015	.013
W1.4		0.134	.049	.084	.056	.042	.028	.028	.017	.014	.011	.009

Note: For other available wire sizes other than those listed, contact your nearest WWR manufacturer.

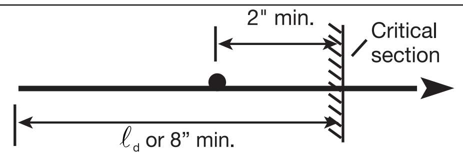
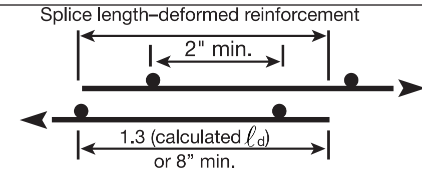
TABLE 5M Metric Units

Wire Size Plain	Number Deformed	Nominal Diameter *mm*	Nominal Mass *kg/m*	As - mm^2 Per Meter *Center to Center Spacing (mm)*								
				51	76	102	152	203	254	305	406	457
MW 290	MD 290	19.23	2.28	5686	3816	2843	1908	1429	1142	951	714	635
MW 200	MD 200	15.96	1.57	3922	2632	1961	1316	985	787	656	493	438
MW 129	MD 129	12.83	1.01	2540	1693	1270	847	635	508	423	318	282
MW 116	MD 116	12.17	0.911	2286	1524	1143	762	572	457	381	286	254
MW 103	MD 103	11.46	0.809	2032	1355	1016	677	508	406	339	254	225
MW 90	MD 90	10.72	0.708	1778	1185	889	593	445	356	296	222	197
MW 77	MD 77	9.93	0.607	1524	1016	762	508	381	305	254	190	168
MW 71	MD 71	9.50	0.556	1397	931	699	466	349	279	233	175	155
MW 68		9.30	0.531	1334	889	667	445	332	267	222	167	149
MW 65	MD 65	9.07	0.506	1270	847	635	423	318	254	212	160	142
MW 61		8.84	0.481	1207	804	603	402	301	241	201	150	133
MW 58	MD 58	8.59	0.456	1143	762	572	381	286	229	191	143	127
MW 55		8.36	0.430	1080	720	540	360	269	216	180	135	120
MW 52	MD 52	8.10	0.405	1016	677	508	339	254	203	169	128	114
MW 48		7.85	0.379	953	635	476	318	237	191	159	118	105
MW 45	MD 45	7.60	0.354	889	593	445	296	222	178	148	111	98
MW 42		7.32	0.329	826	550	413	275	205	165	138	103	92
MW 39	MD 39	7.01	0.304	762	508	381	254	191	152	127	96	85
MW 36		6.73	0.278	699	466	349	233	174	140	116	89	79
MW 32	MD 32	6.40	0.253	635	423	318	212	159	127	106	78	70
MW 29		6.07	0.228	572	381	286	191	142	114	95.3	71	63
MW 26	MD 26	5.74	0.202	508	339	254	169	127	102	84.7	64	57
MW 23		5.36	0.177	445	296	222	148	110	88.9	74.1	56	50
MW 19		4.95	0.152	381	254	191	127	95.3	76.2	63.5	47	42
MW 16		4.52	0.126	317	212	159	106	78.3	63.5	52.9	39	35
MW 14		4.11	0.106	267	178	133	88.9	65.6	52.9	44.5	34	31
MW 13		4.06	0.101	254	169	127	84.7	63.5	50.8	42.3	32	28
MW 10		3.51	0.076	191	127	95.3	63.5	48.4	38.1	31.8	25	22
MW 9		3.40	0.071	178	119	88.9	59.3	44.5	36.0	29.6	22	20

Note: For other available wire sizes other than those listed, contact your nearest WWR manufacturer.

TABLE 6♦ Customary Units (in.-lb.)
Welded Deformed Wire Reinforcement

Typical Development and Splice Length, inches
Welded Deformed Wire Reinforcement f_y = 60,000 psi f'_c = 4,000 psi

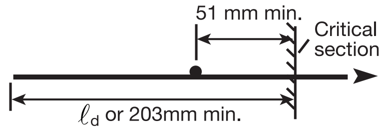
WIRES TO BE DEVELOPED OR SPLICED						
			Splice length when sum of overhang is *:			
Wire Size	S_w, spacing in.	ℓ_d	0"	6"	8"	12"
D4	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D5	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D6	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D7	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D8	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D9	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D10	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D12	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D14	4	8	8	8	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D16	4	8	9	9	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D18	4	8	10	10	10	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D20	4	9	12	12	12	14
	6	8	8	8	10	14
	12	8	8	8	10	14
D31	4	17	22	22	22	22
	6	11	15	15	15	15
	12	9	12	12	12	14
D45	4	27	35	35	35	35
	6	18	23	23	23	23
	12	12	16	16	16	16

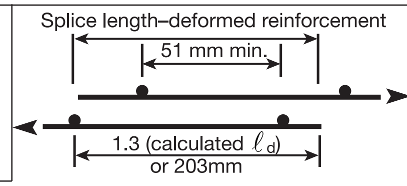
* Splice length determined using calculated l_d.

♦ Assumed 3/4" concrete cover.

TABLE 6M♦ Metric Units (mm)
Welded Deformed Wire Reinforcement

Typical Development and Splice Length, millimeters*
f_y = 414 MPa f'_c = 28 MPa





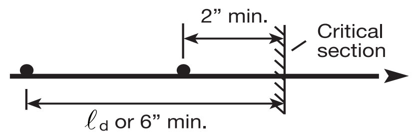
WIRES TO BE DEVELOPED OR SPLICED			Splice length when sum of overhang is *:			
Wire Size	**S_w, spacing in.**	**ℓ_d**	**0 mm**	**152 mm**	**203 mm**	**305 mm**
MD 26	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 32	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 39	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 45	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 52	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 58	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 65	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 77	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 90	102	203	203	203	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 103	102	203	203	229	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 116	102	203	254	254	254	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 130	102	229	305	305	305	356
	152	203	203	203	254	356
	305	203	203	203	254	356
MD 200	102	432	559	559	559	559
	152	279	381	381	381	381
	305	229	305	305	305	356
MD 290	102	686	889	889	889	889
	152	457	584	584	584	584
	305	305	406	406	406	406

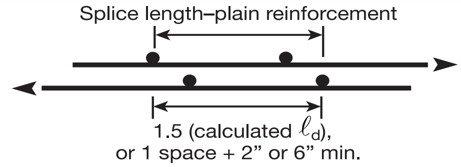
* Splice length determined using calculated ℓ_d.

♦ Assumed 20 mm concrete cover.

TABLE 7 Customary Units (in.)
Welded Plain Wire Reinforcement

Typical Development and Splice Lengths, inches
f_y = 60,000 psi f'_c = 4,000 psi

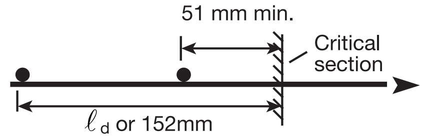


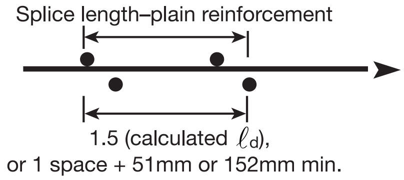


WIRES TO BE DEVELOPED OR SPLICED		Development length when cross-wire spacing is:				Splice length when cross-wire spacing is:			
Wire Size	**Sw, spacing in.**	**4”**	**6”**	**8”**	**12”**	**4”**	**6”**	**8”**	**12”**
W1.4	4	6	8	10	14	6	8	10	14
to	6	6	8	10	14	6	8	10	14
W5	12	6	8	10	14	6	8	10	14
W6	4	6	8	10	14	6	8	10	14
	6	6	8	10	14	6	8	10	14
	12	6	8	10	14	6	8	10	14
W7	4	6	8	10	14	7	8	10	14
	6	6	8	10	14	6	8	10	14
	12	6	8	10	14	6	8	10	14
W8	4	6	8	10	14	8	8	10	14
	6	6	8	10	14	6	8	10	14
	12	6	8	10	14	6	8	10	14
W9	4	6	8	10	14	9	10	10	14
	6	6	8	10	14	6	8	10	14
	12	6	8	10	14	6	8	10	14
W10	4	7	8	10	14	10	10	10	14
	6	6	8	10	14	7	8	10	14
	12	6	8	10	14	6	8	10	14
W12	4	8	8	10	14	12	12	12	14
	6	6	8	10	14	8	8	10	14
	12	6	8	10	14	6	8	10	14
W14	4	9	9	10	14	14	14	14	14
	6	6	8	10	14	9	9	10	14
	12	6	8	10	14	6	8	10	14
W16	4	11	11	11	14	16	16	16	16
	6	7	8	10	14	11	11	11	14
	12	6	8	10	14	6	8	10	14
W18	4	12	12	12	14	18	18	18	18
	6	8	8	10	14	12	12	12	14
	12	6	8	10	14	6	8	10	14
W20	4	13	13	13	14	20	20	20	20
	6	9	9	10	14	13	13	13	14
	12	6	8	10	14	8	8	10	14
W31	4	20	20	20	20	30	30	30	30
	6	14	14	14	14	20	20	20	20
	12	7	8	10	14	10	10	10	14
W45	4	29	29	29	29	44	44	44	44
	6	19	19	19	19	29	29	29	29
	12	10	10	10	10	15	15	15	15

TABLE 7M Metric Units (mm)
Welded Plain Wire Reinforcement

Typical Development and Splice Lengths (millimeters)
f_y = 414 MPa f'_c = 28 MPa





WIRES TO BE DEVELOPED OR SPLICED		Development length when cross-wire spacing is:				Splice length when cross-wire spacing is:			
Wire Size	**mm**	**102mm**	**152mm**	**203mm**	**305mm**	**102mm**	**152mm**	**203mm**	**305mm**
MW9 to MW32	102	152	203	254	356	152	203	254	356
	152	152	203	254	356	152	203	254	356
	305	152	203	254	356	152	203	254	356
MW39	102	152	203	254	356	152	203	254	356
	152	152	203	254	356	152	203	254	356
	305	152	203	254	356	152	203	254	356
MW45	102	152	203	254	356	178	203	254	356
	152	152	203	254	356	152	203	254	356
	305	152	203	254	356	152	203	254	356
MW52	102	152	203	254	356	203	203	254	356
	152	152	203	254	356	152	203	254	356
	305	152	203	254	356	152	203	254	356
MW58	102	152	203	254	356	229	254	254	356
	152	152	203	254	356	152	203	254	356
	305	152	203	254	356	152	203	254	356
MW65	102	178	203	254	356	254	254	254	356
	152	152	203	254	356	178	203	254	356
	305	152	203	254	356	152	203	254	356
MW77	102	203	203	254	356	305	305	305	356
	152	152	203	254	356	203	203	254	356
	305	152	203	254	356	152	203	254	356
MW90	102	229	229	254	356	356	356	356	356
	152	152	203	254	356	229	229	254	356
	305	152	203	254	356	152	203	254	356
MW103	102	279	279	279	356	406	406	406	406
	152	178	203	254	356	279	279	279	356
	305	152	203	254	356	152	203	254	356
MW116	102	305	305	305	356	457	457	457	457
	152	203	203	254	356	305	305	305	356
	305	152	203	254	356	152	203	254	356
MW130	102	330	330	330	356	508	508	508	508
	152	229	229	254	356	330	330	330	356
	305	152	203	254	356	203	203	254	356
MW200	102	584	584	584	584	864	864	864	864
	152	381	381	381	381	584	584	584	584
	305	203	203	254	356	305	305	305	305
MW290	102	838	838	838	838	1270	1270	1270	1270
	152	559	559	559	559	838	838	838	838
	305	279	279	279	356	432	432	432	432

TABLE 8 Wire Size Comparison (When customary units are specified)

W & D Wire Size* Plain*	W & D Metric Wire Size (Conversion) Plain**	CUSTOMARY UNITS			METRIC UNITS (conversions)		
		Area (sq. in.)	Diameter (in.)	Nominal Weight (lb./ft.)	Nominal Area (mm^2)	Nominal Diameter (mm)	Nominal Mass (kg/m)
W45	MW 290	.45	.757	1.530	290	19.23	2.28
W31	MW 200	.31	.628	1.054	200	15.96	1.57
W20	MW 130	.200	.505	.680	129	12.8	1.01
	MW 122	.189	.490	.643	122	12.4	0.96
W18	MW 116	.180	.479	.612	116	12.2	0.91
	MW 108	.168	.462	.571	108	11.7	0.85
W16	MW 103	.160	.451	.544	103	11.5	0.81
	MW 94	.146	.431	.495	94	10.9	0.74
W14	MW 90	.140	.422	.476	90	10.7	0.71
	MW 79	.122	.394	.414	79	10.0	0.62
W12	MW 77	.120	.391	.408	77	9.9	0.61
W11	MW 71	.110	.374	.374	71	9.5	0.56
W10.5	MW 68	.105	.366	.357	68	9.3	0.53
	MW 67	.103	.363	.351	67	9.2	0.52
W10	MW 65	.100	.357	.340	65	9.1	0.51
W9.5	MW 61	.095	.348	.323	61	8.8	0.48
W9	MW 58	.090	.338	.306	58	8.6	0.45
	MW 56	.086	.331	.292	55.5	8.4	0.43
W8.5	MW 55	.085	.329	.289	54.9	8.4	0.43
W8	MW 52	.080	.319	.272	52	8.1	0.40
W7.5	MW 48	.075	.309	.255	48.4	7.8	0.38
W7	MW 45	.070	.299	.238	45	7.6	0.35
W6.5	MW 42	.065	.288	.221	42	7.3	0.33
	MW 41	.063	.283	.214	41	7.2	0.32
W6	MW 39	.060	.276	.204	39	7.0	0.30
W5.5	MW 36	.055	.265	.187	35.5	6.7	0.28
	MW 35	.054	.263	.184	34.8	6.7	0.27
W5	MW 32	.050	.252	.170	32	6.4	0.25
	MW 30	.047	.244	.158	30	6.2	0.24
	MW 29	.045	.239	.153	29	6.1	0.23
W4	MW 26	.040	.226	.136	26	5.7	0.20
W3.5	MW 23	.035	.211	.119	23	5.4	0.18
W2.9	MW 19	.029	.192	.098	19	4.9	0.15
W2.0	MW 13	.020	.160	.068	13	4.1	0.10
W1.4	MW 9	.014	.135	.048	9	3.4	0.07

* For deformed wire, change W to D.
** For deformed wire (metric) change MW to MD.

TABLE 8M Wire Size Comparison (When Metric Units are specified)

Metric Units				Inch-pound Units (conversions)				Gage Guide
Size * (MW=Plain) (mm^2)	Area (mm^2)	Diameter (mm)	Mass (kg/m)	Nominal Size * (W=Plain) (in^2x100)	Area (in^2)	Diameter (in)	Weight (lb./ft.)	
MW290	290	19.23	2.28	W45	.450	.757	1.53	
MW200	200	15.96	1.57	W31	.310	.628	1.054	
MW130	130	12.9	1.02	W20.2	.202	.507	.687	
MW120	120	12.4	.941	W18.6	.186	.487	.632	7/0
MW100	100	11.3	.784	W15.5	.155	.444	.527	6/0
MW90	90	10.7	.706	W14.0	.140	.422	.476	5/0
MW80	80	10.1	.627	W12.4	.124	.397	.422	
MW70	70	9.4	.549	W10.9	.109	.373	.371	4/0
MW65	65	9.1	.510	W10.1	.101	.359	.343	3/0
MW60	60	8.7	.470	W9.3	.093	.344	.316	
MW55	55	8.4	.431	W8.5	.085	.329	.289	2/0
MW50	50	8.0	.392	W7.8	.078	.314	.263	
MW45	45	7.6	.353	W7.0	.070	.298	.238	1/0
MW40	40	7.1	.314	W6.2	.062	.283	.214	1
MW35	35	6.7	.274	W5.4	.054	.262	.184	2
MW30	30	6.2	.235	W4.7	.047	.245	.160	3
MW26	26	5.7	.204	W4.0	.040	.226	.136	4
MW25	25	5.6	.196	W3.9	.039	.223	.133	
MW20	20	5.0	.157	W3.1	.031	.199	.105	
MW19	19	4.9	.149	W2.9	.029	.192	.098	6
MW15	15	4.4	.118	W2.3	.023	.171	.078	
MW13	13	4.1	.102	W2.0	.020	.160	.068	8
MW10	10	3.6	.078	W1.6	0.16	.143	.054	
MW9	9	3.4	.071	W1.4	.014	.135	.048	10

Note * Wires may be deformed, use prefix MD or D, except where only MW or W is required by building codes (usually less than MW26 or W4). For other available wire sizes, consult other WRI publications or discuss with WWR manufacturers.

Welded wire reinforcement sheets are shipped bundled in quantities depending on size of sheets and corresponding weights in accordance with customers' requirements and capacities. Most bundles will weigh between 2,000 and 5,000 pounds.

The bundles are bound together using steel strapping. It is very important to note that the strapping is selected and installed for the sole purpose of holding the sheets together during shipping and unloading and should NEVER be used to lift the bundles.

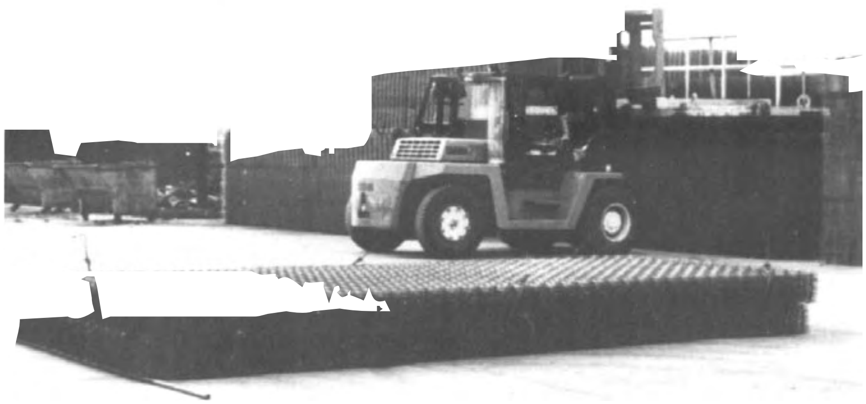
Sometimes bundles are assembled by flipping alternate sheets, allowing the sheets to "nest". This allows for a greater number of sheets to be stacked in a given height and provides some benefit in added stability. Unless required by the customer, sheets are not flipped. Stacks do not exceed 5 feet in height above the trailer bed.

Once sheets are bundled, they are transported to storage or loading areas by forklift trucks or overhead cranes. Bundles of relatively short sheets can be handled by forklifts alone. Sheets of longer lengths are handled by either forklift trucks with sheet dollies, roller conveyors or overhead cranes to the storage and loading areas. Many times a combination of material handling equipment is used to move material through the plant and to the storage and loading area.

Generally, shorter sheets are loaded onto flatbed trailers using forklifts. Longer sheets are usually loaded with an overhead crane or forklift truck using a spreader bar or sheet pick-up frame with a 6-point pick-up so that longer sheets will not deflect or bend excessively when lifted. Cables or chains are passed through the bundles and fastened to the bottom wires.

After the sheet bundles are loaded onto the flatbed trailer, they are secured to the flatbed using chains and binders, nylon straps, steel strapping, or a combination of these devices, in accordance with applicable federal, state and local safety regulations.

At the shipping destination (either job site or storage facility), the bundles are removed in much the same manner in which loaded. Where forklifts are not available, front end loaders equipped with lifting chains may be used. Similar to the overhead cranes used for lifting bundles at the manufacturer's plant, truck cranes, tower cranes or hydraulic cranes may be used for off-loading at the job site or storage facility. If it is anticipated that the bundles will be lifted by crane in the field, the customer should request that lifting eyes be provided. Lifting eyes are generally lengths of rod that are passed completely through the underside of the bundle and brought back to the top and twisted around 3-4 times to form an eye. They are placed 2'-3' from the ends and sides to limit deflecting and bending in the center of the bundles. Extreme caution should be exercised to assure that the lifting eyes have been placed and sizes sufficiently to carry the load.



Sheet bundles not ordered with lifting eyes are placed on dunnage spaced every 3 to 4 feet 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 off-loading of materials requiring lifting equipment, extreme caution should be exercised and all safety regulations and practices must be observed.

The engineer specifies the amount of reinforcement required and the correct position for the reinforcement within a wall or slab. To ensure proper performance of the reinforcement, it is essential that the welded wire reinforcement sheets be placed on supports to maintain their required position during concrete placement.

The supports (either concrete blocks, steel or plastic "chair" devices, or a combination of these) must be appropriately spaced in order to work effectively.

The various codes and standards do not give advice on spacing of supports for WWR. The WRI Tech Fact, TF 702 R2 does have guidelines for support spacing based on many years of experience. The TF can be downloaded from the publications listing on the WRI website. Simply stated:

Wire Size	Recommended For Wire Spacing	Support Spacing
W or D9 and larger*	12" and greater	4 - 6 ft.
W or D5 to W or D8	12" and greater	3 - 4 ft.
W or D9 and larger*	Less than 12"	3 - 4 ft.
W or D4 or W or D8	Less than 12"	2 - 3 ft.
Less than W or D4**	Less than 12"	2 - 3 ft. or less

The above guidelines for WWR support spacings can be used for supported concrete slabs whether formed or placed on composite metal decks.

* Spacing of supports for WWR with wire sizes larger than W or D9 could be increased over the spacings shown depending on the construction loads applied.

**Consider additional rows of supports when permanent deformations occur - on the other hand - spacing of supports may be increased provided supports are properly positioned just as concrete is being placed.

Types of Supports - There are a variety of supports made specifically for WWR. The TF 702 R2 has photos of some of them. The same companies that sell rebar supports will usually handle those shown in the TF as well. Call the WRI if you need the references to any specific support and manufacturer.

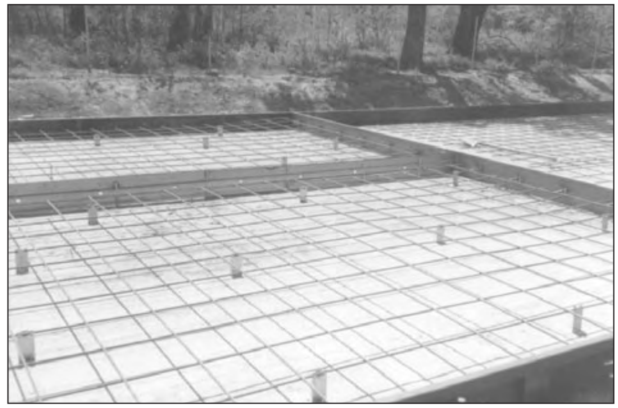
(Above)

1- Cut every other wire at contraction joints. While maintaining continuity, restraint is relieved, when some area of reinforcing is reduced for slabs on ground.

2- Welded wire is supported on steel wire chairs. Note stiffness of WWR.

3- Welded wire used in repairing the Ohio Turnpike.

4- Lazer streeds can ride over supported WWR. Maintain proper positioning when WWR is displaced.



1

2

3

4

Welded Wire Weight (Mass) Calculations

Calculated actual weight of a reinforcement item is determined by computing the weights of longitudinal and transverse wires separately, then adding the two results:

Calculated actual weight = Longitudinal weight + transverse weight

Longitudinal weight = $wt_t \times N_1 \times L$ (round to 1 decimal place)

Transverse weight = $Wt_1 \times N_1 \times OW$ (round to 1 decimal place)

where: Wt_1 = Unit weight of one longitudinal wire (lbs./ft. or kg/m)

Wt_t = Unit weight of one transverse wire (lbs./ft. or kg/m)

N_1 = Number of longitudinal wires

N_t = Number of transverse wires

L = Length of sheet (ft. or m)

OW = Overall width = length of transverse wires (ft. or mm)

$$N_1 = \frac{\text{Width (inches or mm)}}{\text{Longitudinal spacing}} + 1$$ for uniformly spaced reinforcement

$$N_t = \frac{\text{Length (inches or mm)}}{\text{Transverse spacing}}$$ for uniformly spaced reinforcement

Guidelines for Calculating Wire Area Weight (Mass) and Diameter

Cross-sectional area of wire is taken as nominal area. Weight and nominal diameter are based on area figure.

Symbol	Description	Units	Metric
A	= Cross-sectional area of one wire	sq. in.	mm2
Wt	= Unit weight of one wire	lbs./ft.	kg/m
d	= Nominal diameter of one wire	in.	mm

A = "W" - number ÷ 100

Wt = A x 3.4

$$d = \sqrt{\frac{A}{.7854}}$$

Mass (kg/m) Mass = Area in mm2 x 0.00785

Example of Weight (Mass) Calculations

Item 1. 6 x 8-W10 x D12–96" (+0", +6") x 20'-8" sheets

Item 2. 6 x 6-W2.9 x W2.9–72" (+0, +0") x 20'-0" sheets

Item 1M.

152 x 203–MW65 x MD77–2438 (+0 +152) x 6.3m

Item 2M.

152 x 152–MW19 x MW19–1830 (+0 +0) x 6.1m

Calculated Actual Weights (Customary Units)

	Wire Size	Wt (lb/ft)	N	L or OW (ft.)	Calc. Weight
Item 1					
Longitudinal Wires	W10	.340	17	20.67	119.5
Transverse Wires	D12	.408	31	8.50	107.5
Calc. Weight					227.0 Lbs./Sheet
Item 2					
Longitudinal Wires	W2.9	.099	13	20.00	25.7
Transverse Wires	W2.9	.099	40	6.00	23.8
Calc. Weight					49.5 Lbs./Sheet

Calculated Actual Mass (Metric Units)

	Wire Size	Mass (kg/m)	N	L or OW (m)	Calc. Mass
Item 1M					
Longitudinal Wires	MW65	.506	17	6.3	54.2 kg.
Transverse Wires	MD77	.607	31	2.59	48.7 kg.
Calc. Mass					102.9 Kgs./Sheet
Item 2M					
Longitudinal Wires	MW19	.147	13	6.1	11.7
Transverse Wires	MW19	.147	40	1.83	10.8
Calc. Mass					22.5 Kgs./Sheet

Calculated Unit Weights

	Calc. weight ÷	Area *	x 100 = #/csft
Item 1	227.0	20.67 x 8.50 = 175.70	129
Item 2	49.5	20.00 x 6.00 + 120.0	41

* Item 1. Area = length x overall width
Item 2. Area = length x width
Round #/100 Sq. Ft. to full number

Calculated Unit Mass

	Calc. mass ÷	Area*	= kg./m2
Item 1	102.9	6.3 x 2.59 = 16.32	6.31
Item 2	22.5	6.1 x 1.83 = 11.2	2.0

* Item 1. Area = length x overall width
Item 2. Area = length x width

TABLE 9 Weight of Longitudinal Wires

Weight (Mass) Estimating Tables

Weight in Pounds per 100 Sq. Ft. for all Styles Having Uniform Spacing of Wires

Based on 60" width center to center of outside longitudinal wires.

WIRE SIZE (W or D)	NOMINAL DIAMETER INCHES	SPACING AND WEIGHT OF LONGITUDINAL WIRES										
		2"	3"	4"	5"	6"	8"	9"	10"	12"	16"	18"
45	0.757	948.60	642.60	489.60	397.80	336.60	260.10	234.40	214.20	183.60	145.35	132.98
31	0.628	653.48	442.68	337.28	274.04	231.88	179.18	161.68	147.56	126.48	100.13	91.28
30	0.618	632.40	428.40	326.40	265.20	224.40	173.40	156.46	142.80	122.40	96.90	88.33
28	0.597	590.24	399.84	304.64	247.52	209.44	161.84	146.03	133.28	114.24	90.44	82.44
26	0.576	548.08	371.28	282.88	229.84	194.48	150.28	135.60	123.76	106.08	83.98	76.55
24	0.553	505.92	342.72	261.12	212.16	179.52	138.72	125.17	114.24	97.92	77.52	70.67
22	0.529	463.76	314.16	239.36	194.48	164.56	127.16	114.74	104.72	89.76	71.06	64.78
20	0.504	421.60	285.60	217.60	176.80	149.60	115.60	104.31	95.20	81.60	64.60	58.89
18	0.478	379.44	257.04	195.84	159.12	134.64	104.04	93.88	85.68	73.44	58.14	53.00
16	0.451	337.28	228.48	174.48	141.44	119.68	92.48	83.45	76.16	65.28	51.68	47.11
14	0.422	295.12	199.92	152.32	123.76	104.72	80.92	73.01	66.64	57.12	45.22	41.22
12	0.391	252.96	171.36	130.56	106.08	89.76	69.36	62.58	57.12	48.96	38.76	35.33
11	0.374	231.88	157.08	119.68	97.24	82.28	63.58	57.37	52.36	44.88	35.53	32.39
10.5	0.366	221.34	149.94	114.24	92.82	78.54	60.69	54.76	49.98	42.84	33.91	30.92
10	0.356	210.80	142.80	108.80	88.40	74.80	57.80	52.15	47.60	40.80	32.30	29.44
9.5	0.348	200.26	135.66	103.36	83.98	71.06	54.91	49.55	45.22	38.76	30.69	27.97
9	0.338	189.72	128.52	97.92	79.56	67.32	52.02	46.94	42.84	36.72	29.07	26.50
8.5	0.329	179.18	121.38	92.48	75.14	63.58	49.13	44.33	40.46	34.68	27.46	25.03
8	0.319	168.64	114.24	87.04	70.72	59.84	46.24	41.73	38.08	32.64	25.84	23.56
7.5	0.309	158.10	107.10	81.60	66.30	56.10	43.35	39.11	35.70	30.60	24.23	22.08
7	0.298	147.56	99.96	76.16	61.88	52.36	40.46	36.51	33.32	28.56	22.61	20.61
6.5	0.288	137.02	92.82	70.72	57.46	48.62	37.57	33.90	30.94	26.52	21.00	19.14
6	0.276	126.48	85.68	65.28	53.04	44.88	34.68	31.29	28.56	24.48	19.38	17.67
5.5	0.264	115.94	78.54	69.84	48.62	41.14	31.79	28.69	26.18	22.44	17.77	16.19
5	0.252	105.40	71.40	54.40	44.20	37.40	28.90	36.08	23.80	20.40	16.15	14.72
4.5	0.240	94.86	64.26	48.96	39.78	33.66	26.01	23.47	21.42	18.36	14.54	13.25
4	0.225	84.32	57.12	43.52	35.36	29.92	23.12	20.87	19.04	16.32	12.92	11.78
3.5	0.211	73.78	49.98	38.08	30.94	26.18	20.23	18.26	16.66	14.28	11.31	10.31
3	0.195	63.24	42.84	32.64	26.52	22.44	17.34	15.65	14.28	12.24	9.69	8.83
2.9	0.192	61.13	41.14	31.55	25.64	21.69	16.76	15.13	13.80	11.83	9.37	8.54
2.5	0.178	52.70	35.70	27.20	22.10	18.70	14.45	13.04	11.90	10.20	8.08	7.36
2.1	0.162	44.27	29.99	22.85	18.56	15.71	12.14	10.95	10.00	8.56	6.78	6.18
2	0.159	42.16	28.56	21.76	17.68	14.96	11.56	10.44	9.52	8.16	6.46	5.89
1.5	0.138	31.62	21.42	16.32	13.26	11.22	8.67	7.83	7.14	6.12	4.85	4.42
1.4	0.134	29.51	19.99	15.23	12.38	10.47	8.09	7.30	6.66	5.71	4.52	4.12

NOTES:

(1) This table is to be used for estimating purposes only. Exact weights of welded wire reinforcement will vary from those shown above, depending upon width of sheets and length of overhangs.

(See example,page 32.)

(2) Deformed wires (D prefix) usually are not produced in sizes smaller than D4.

TABLE 9M Mass of Longitudinal Wires (Mass in kg/m² for all styles)
Based on 1524mm width center to center of outside longitudinal wires

meters = m
millimeters = mm

W or D	Wire Size *MW or MD*	Nominal Diameter	SPACING AND WEIGHT OF LONGITUDINAL WIRES										
			51 mm	76 mm	102 mm	127 mm	152 mm	203 mm	229 mm	254 mm	305 mm	406 mm	457 mm
45	290.0	19.23	46.31	31.37	23.90	19.42	16.43	12.71	11.44	10.46	8.96	7.10	6.47
31	200.0	15.96	31.94	21.59	16.45	13.37	11.31	8.74	7.89	7.20	6.17	4.89	4.46
30	194	15.70	30.84	20.89	15.92	12.93	10.94	8.36	7.63	6.96	5.97	4.75	4.33
28	181	15.16	28.79	19.50	14.86	12.07	10.22	7.89	7.12	6.50	5.57	4.43	4.04
26	168	14.61	26.73	18.11	13.80	11.21	9.49	7.33	6.61	6.04	5.17	4.11	3.75
24	155	14.05	24.68	16.72	12.74	10.35	8.76	6.77	6.15	5.57	4.78	3.79	3.46
22	142	13.44	23.60	15.32	11.67	9.49	8.03	6.20	5.60	5.11	4.38	3.47	3.17
20	129	12.80	20.56	13.94	10.61	8.62	7.30	5.84	5.09	4.64	3.98	3.16	2.88
18	116	12.14	18.51	12.54	9.55	7.76	6.57	5.07	4.58	4.23	3.58	2.84	2.59
16	103	11.46	16.45	11.14	8.49	6.90	5.84	4.51	4.07	3.71	3.18	2.52	2.30
14	90	10.72	14.39	9.75	7.43	6.04	5.11	3.95	3.55	3.25	2.79	2.20	2.01
12	77	9.91	12.34	8.38	6.37	6.17	4.38	3.38	3.05	2.79	2.39	1.88	1.72
11	71	9.50	11.31	7.66	5.81	4.74	4.01	3.10	2.80	2.55	2.19	1.74	1.58
10.5	68	9.30	10.80	7.31	5.57	4.53	3.83	2.96	2.67	2.44	2.09	1.66	1.52
10	65	9.04	10.27	6.96	5.31	4.31	3.65	2.82	2.54	2.32	1.99	1.59	1.45
9.5	61	8.84	9.77	6.62	5.04	4.10	3.47	2.68	2.42	2.21	1.89	1.49	1.36
9	58	8.59	9.25	6.27	4.78	3.88	3.28	2.54	2.29	2.09	1.79	1.42	1.29
8.5	55	8.38	8.74	5.82	4.56	3.66	3.10	2.40	2.16	1.97	1.69	1.35	1.27
8	52	8.10	8.23	5.57	4.25	3.45	2.92	2.26	2.04	1.86	1.59	1.27	1.16
7.5	48	7.85	7.71	5.22	3.98	3.23	2.74	2.11	1.91	1.74	1.49	1.17	1.07
7	45	7.57	7.20	4.88	3.71	3.02	2.55	1.97	1.78	1.63	1.39	1.10	1.00
6.5	42	7.32	6.68	4.53	3.45	2.80	2.37	1.83	1.65	1.51	1.29	1.03	0.94
6	39	7.01	6.17	4.18	3.18	2.59	2.19	1.69	1.53	1.39	1.19	0.95	0.87
5.5	36	6.78	5.65	3.83	2.92	2.37	2.01	1.55	1.40	1.28	1.09	0.88	0.80
5	33	6.40	5.14	3.48	2.65	2.18	1.82	1.41	1.27	1.18	0.99	0.81	0.74
4.5	29	6.07	4.63	3.13	2.39	1.94	1.64	1.27	1.14	1.04	0.90	0.71	0.65
4	26	5.72	4.11	2.79	2.12	1.72	1.46	1.13	1.02	0.93	0.80	0.64	0.58
3.5	23	5.35	3.60	2.44	1.86	1.51	1.28	0.99	0.89	0.81	0.70	0.56	0.51
3	19	4.95	4.06	2.09	1.59	1.29	1.09	0.85	0.76	0.70	0.60	0.47	0.42
2.9	19	4.88	2.98	2.09	1.59	1.29	1.09	0.85	0.76	0.70	0.60	0.47	0.42
2.5	16	4.53	2.57	1.74	1.33	1.08	0.91	0.70	0.64	0.58	0.50	0.39	0.36
2.1	13.5	4.15	2.15	1.46	1.11	0.90	0.76	0.59	0.53	0.49	0.42	0.33	0.30
2	13	4.04	2.06	1.39	1.03	0.87	0.73	0.56	0.51	0.46	0.40	0.32	0.29
1.5	10	3.51	1.54	1.04	0.82	0.65	0.55	0.42	0.38	0.35	0.30	0.24	0.22
1.4	9	3.39	1.44	0.97	0.74	0.60	0.51	0.39	0.35	0.32	0.28	0.22	0.20

NOTES: **(1)** This table is to be used for estimating purposes only. Exact weights of welded wire reinforcement will vary from those shown above, depending upon width of sheets and length of overhangs.

(See example,page 33.)

(2) Deformed wires (D prefix) usually are not produced in sizes smaller than D4.

TABLE 10 **Weight of Transverse Wires**
Based on 62” lengths of transverse wire (60” width plus 1”overhang each side).
Weights in pounds per 100 sq. ft.

WIRE SIZE (W or D)	NOMINAL DIAMETER INCHES	SPACING AND WEIGHT OF TRANSVERSE WIRES										
		2”	3”	4”	5”	6”	8”	9”	10”	12”	16”	18”
45	0.757	948.6	632.40	474.30	379.44	316.20	237.15	210.75	189.72	158.10	118.57	105.41
31	0.628	653.48	435.65	326.74	261.39	217.83	163.37	145.22	130.70	108.91	81.68	72.61
30	0.618	632.40	421.40	316.20	252.96	210.80	158.10	140.53	126.48	105.40	79.05	70.27
28	0.587	590.24	393.49	295.12	236.10	196.75	147.56	131.17	118.05	98.37	73.78	65.59
26	0.575	548.08	365.38	274.04	219.23	182.70	137.02	121.80	109.62	91.34	68.51	60.90
24	0.553	505.92	337.28	252.96	202.37	168.64	126.48	112.43	101.18	84.32	63.24	56.22
22	0.529	463.76	309.17	231.88	185.50	154.59	115.94	103.06	92.75	77.29	57.97	51.53
20	0.504	421.60	281.06	210.80	168.64	140.53	105.40	93.69	84.32	70.26	52.70	46.84
18	0.478	379.44	252.96	189.72	151.78	126.48	94.86	84.32	75.89	63.24	47.43	42.16
16	0.451	337.28	224.85	168.64	134.91	112.43	84.32	74.95	67.46	56.21	42.16	37.48
14	0.422	295.12	196.76	147.56	118.05	98.37	73.78	65.58	59.02	49.19	36.89	32.79
12	0.391	252.96	168.64	126.48	101.18	84.32	63.24	56.21	50.59	42.16	31.62	28.11
11	0.374	231.88	154.59	115.94	92.75	77.29	57.97	51.53	46.38	38.65	28.98	25.77
10.5	0.366	221.34	147.56	110.67	88.54	73.78	55.34	49.19	44.27	36.89	27.87	24.59
10	0.356	210.80	140.53	105.40	84.32	70.27	52.70	46.84	42.16	35.13	26.35	23.42
9.5	0.348	200.28	133.51	100.13	80.11	66.76	50.07	44.50	40.05	33.38	25.03	22.25
9	0.338	189.72	126.48	94.86	75.89	63.24	47.43	42.16	37.94	31.62	23.71	21.08
8.5	0.329	179.18	119.45	89.59	71.67	59.73	44.80	39.82	35.84	29.86	22.40	19.91
8	0.319	168.64	112.43	84.32	67.46	56.21	42.16	37.48	33.73	28.11	21.08	18.74
7.5	0.309	158.10	105.40	79.05	63.24	52.70	39.53	35.14	31.62	26.35	19.76	17.57
7	0.298	147.56	98.37	73.78	59.02	49.19	36.89	32.79	29.51	24.59	18.44	16.40
6.5	0.288	137.02	91.35	68.51	54.81	45.68	34.26	30.45	27.41	22.84	17.13	15.23
6	0.276	126.48	84.32	63.24	50.59	42.16	31.62	28.11	25.30	21.08	15.81	14.05
5.5	0.264	115.94	77.30	57.97	46.38	38.65	28.99	25.77	23.19	19.33	14.49	12.88
5	0.252	105.40	70.27	52.70	42.16	35.13	26.35	23.42	21.08	17.57	13.17	11.71
4.5	0.240	94.86	63.24	47.43	37.95	31.62	23.72	21.08	18.97	15.81	11.86	10.54
4	0.225	84.32	56.21	42.16	33.73	28.11	21.08	18.74	16.86	14.05	10.54	9.37
3.5	0.211	73.78	49.19	36.89	29.51	24.60	18.45	16.40	14.76	12.30	9.22	8.20
3	0.195	63.24	42.16	31.62	25.30	21.08	15.81	14.05	12.65	10.54	7.90	7.03
2.9	0.192	61.13	40.75	30.57	24.45	20.38	15.28	13.55	12.23	10.18	7.64	6.79
2.5	0.178	52.70	35.13	26.35	21.08	17.57	13.18	11.71	10.54	8.78	6.59	5.86
2.1	0.162	44.26	29.51	22.13	17.71	14.76	11.07	9.81	8.85	7.38	5.53	4.92
2	0.159	42.16	28.11	21.08	16.86	14.05	10.54	9.37	8.43	7.03	5.27	4.68
1.5	0.138	31.62	21.08	15.81	12.65	10.54	7.91	7.03	6.32	5.27	3.95	3.51
1.4	0.134	29.51	19.67	14.76	11.80	9.84	7.38	6.54	5.90	4.92	3.69	3.28

EXAMPLE: Approximate weight of 6 x 6 – W4 x W4
Longitudinal = 29.92
Transverse = 28.11
58.03 lbs. per 100 sq. ft.

TABLE 10M Mass of Transverse Wires (Mass in kg/m² for all styles)

Based on 1575mm lengths of transverse wire (1524mm plus 25.4mm overhang on ea. side)

W or D	Wire Size	Nominal Diameter	SPACING AND WEIGHT OF TRANSVERSE WIRES										
	MW or MD	*mm*	51 mm	76 mm	102 mm	127 mm	152 mm	203 mm	229 mm	254 mm	305 mm	406 mm	457 mm
45	290.0	19.23	46.31	30.87	23.15	18.52	15.43	11.58	10.28	9.26	7.72	5.76	5.15
31	200.0	15.95	32.36	21.25	15.94	12.75	10.62	7.97	7.08	6.37	5.31	3.99	3.46
30	194	15.70	30.84	20.56	15.52	12.34	10.28	7.71	6.85	6.17	5.14	3.86	3.43
28	181	15.16	28.79	19.19	14.44	11.52	9.60	7.20	6.40	5.76	4.80	3.60	3.20
26	168	14.61	26.73	17.82	13.37	10.69	8.91	6.68	5.94	5.35	4.46	3.35	2.97
24	155	14.05	24.88	16.45	12.34	9.87	8.23	6.17	5.48	4.93	4.11	3.09	2.75
22	142	13.44	22.62	15.08	11.31	9.06	7.54	5.65	5.03	4.52	3.77	2.83	2.52
20	129	12.80	20.66	13.71	10.28	8.23	6.85	5.14	4.57	4.11	3.43	2.57	2.29
18	116	12.14	18.51	12.34	9.25	7.40	6.17	4.63	4.11	3.70	3.08	2.32	2.06
16	103	11.46	16.45	10.97	8.23	6.58	5.48	4.11	3.66	3.29	2.74	2.06	1.83
14	90	10.72	14.39	9.60	7.20	5.76	4.80	3.60	3.20	2.88	2.40	1.80	1.60
12	77	9.91	12.34	8.23	6.17	4.93	4.11	3.08	2.74	2.47	2.08	1.54	1.37
11	71	9.60	11.31	7.54	5.65	4.52	3.77	2.83	2.52	2.26	1.89	1.42	1.26
10.5	68	9.30	10.80	7.20	5.40	4.32	3.60	2.70	2.40	2.16	1.80	1.35	1.20
10	65	9.04	10.28	6.85	5.14	4.11	3.43	2.57	2.28	2.06	1.71	1.28	1.14
9.5	61	8.84	9.77	6.51	4.88	3.91	3.26	2.44	2.17	1.95	1.63	1.22	1.09
9	58	8.59	9.25	6.17	4.63	3.70	3.08	2.31	2.06	1.85	1.54	1.16	1.03
8.5	55	8.36	8.74	5.83	4.37	3.50	2.91	2.19	1.94	1.75	1.46	1.09	0.97
8	52	8.10	8.24	5.48	4.11	3.29	2.74	2.06	1.83	1.65	1.37	1.03	0.92
7.5	48	7.85	7.71	5.14	3.86	3.08	2.57	1.93	1.71	1.55	1.29	0.96	0.86
7	45	7.57	7.20	4.80	3.60	2.88	2.40	1.80	1.60	1.44	1.20	0.90	0.80
6.5	42	7.32	6.68	4.45	3.34	2.67	2.23	1.67	1.49	1.34	1.11	0.84	0.74
6	39	7.01	6.17	4.11	3.08	2.47	2.00	1.54	1.37	1.23	1.03	0.77	0.68
5.5	36	6.73	5.65	3.77	2.83	2.26	1.89	1.41	1.26	1.13	0.94	0.71	0.63
5	33	6.40	5.14	3.43	2.57	2.06	1.71	1.29	1.14	1.03	0.86	0.64	0.57
4.5	29	6.07	4.63	3.08	2.31	1.85	1.54	1.16	1.03	0.93	0.77	0.58	0.51
4	26	5.72	4.11	2.74	2.06	1.65	1.27	1.03	0.91	0.82	0.69	0.51	0.46
3.5	23	5.36	3.60	2.40	1.80	1.44	1.20	0.90	0.80	0.72	0.60	0.45	0.40
3	19	4.95	3.08	2.08	1.54	1.23	1.03	0.77	0.69	0.62	0.51	0.39	0.34
2.9	19	4.88	2.98	1.99	1.49	1.19	1.00	0.75	0.66	0.60	0.50	0.37	0.33
2.5	16	4.52	2.57	1.76	1.29	1.03	0.86	0.64	0.57	0.51	0.43	0.32	0.29
2.1	13.5	4.15	2.16	1.44	1.08	0.86	0.72	0.54	0.48	0.43	0.36	0.27	0.24
2	13	4.04	2.06	1.37	1.03	0.81	0.69	0.51	0.46	0.41	0.34	0.26	0.23
1.5	10	3.51	1.54	1.03	0.77	0.62	0.51	0.39	0.34	0.31	0.26	0.19	0.17
1.4	9	3.39	1.44	0.96	0.72	0.58	0.48	0.36	0.32	0.29	0.24	0.18	0.16

EXAMPLE: Approximate mass of 152 x 152 – MW26 x MW26

Longitudinal = 1.46

Transverse = 1.27

2.73 kg/m² (based on 6m length)

NOTES

NOTES

WIRE REINFORCEMENT INSTITUTE

Welded wire, sometimes called fabric or mesh is what we refer to today as “STRUCTURAL WELDED WIRE REINFORCEMENT (WWR)” for concrete construction. The U.S. Patents covering its production were issued in 1901. The Wire Reinforcement Institute, inc. (WRI) was founded in 1930 and has in its Library a hard covered book on triangular wire reinforcement which was published in 1908 by the American Steel & Wire Company (AS&W). In 1911 welded wire machinery arrived and the industry began a new product line for welded wire reinforcement. Considering the time and state of the art of reinforced concrete, the publications printed in those early years were very sophisticated and used by many engineers and contractors on some well known building and paving projects. We are continuing that trend today by keeping you current on the latest materials, technologies and practices.

Activities

- The Institute develops marketing strategies and promotional materials for the purpose of expanding applications and increasing usage of welded wire reinforcing. In addition;
- Prepares reports, presentations, literature, and brochures on the applications and proper use of WWR.
- The Institute provides technical service to users and specifiers of WWR reinforcement such as consulting engineers, architects, developers, contractors, governmental department engineers and others.
- The Institute is involved in cooperative programs with other technical associations with similar interests to advance the use of reinforced concrete.
- WRI provides technical and research service to code bodies and actively participate on various codes and standards committees.
- The Institute library is a source of information on welded wire reinforcement, its proper use and placement.
- The Institute develops programs for the general advancement of the industry involving market studies, research, technical, engineering and promotional work.

Photo captions (back cover)

1.- Structural WWR used in box culverts.
2.- Large cages of WWR confinement reinforcement for high rise buildings.
3.- Bridge "I" girders have WWR shear reinforcement the full length.
4.- A skip pan joist and slab floor system with high strength WWR.

WIRE REINFORCEMENT INSTITUTE

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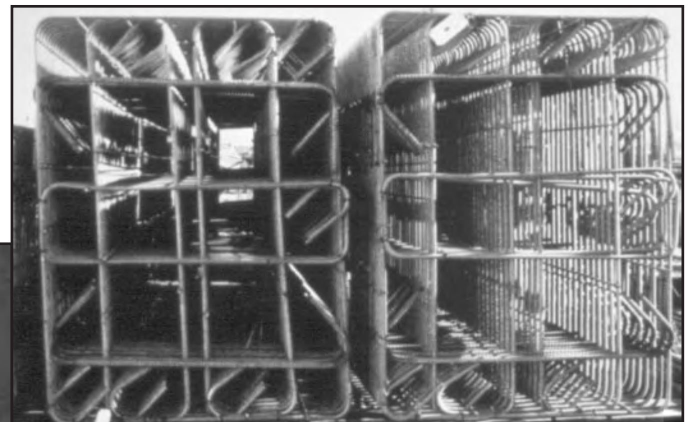

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