TF 311-M-03

WIRE REINFORCEMENT INSTITUTE®

TECH FACTS Excellence Set in Concrete®

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

METRIC WELDED WIRE REINFORCEMENT FOR CONCRETE PIPE

Principles of Reinforcement

When concrete pipe is subjected to a load, either by a testing apparatus or a field installation, this load tries to deform the pipe into an elliptical shape. During the loading process tensile stresses develop on the inside of the pipe at the crown and invert and on the outside of the pipe at the springline, and compressive stresses develop opposite these tensile stresses (Fig. 1). Since concrete is strong in compression but weak in tension, cracks form in the tensile zones. Steel reinforcement in the form of welded wire is used to hold these cracks together, and thus provide structural integrity to the pipe. Although steel reinforcement is not required in the compression zones of the pipe wall, modern manufacturing techniques preclude the steel from being left out of these areas.

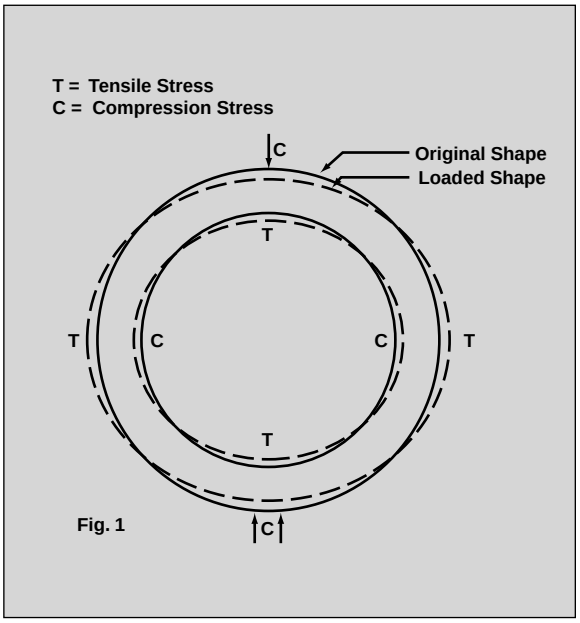


Fig. 1

D-Load Requirements & Manufacturing Specifications

Reinforced concrete pipe is manufactured in accordance with ASTM C-76 & 76M (CSA Standard A-257.2 M). The strength of concrete pipe is stated in terms of D-load which is the load in newtons per linear meter per millimeter of diameter (pounds-force per linear foot per foot of diameter). Concrete pipe that is tested by the three-edge-bearing method is classified according to the D-load that produces a 0.3 mm crack, and the higher D-load that will produce minimum ultimate strength. The D-load strength concept and the statistical evaluation of test results are the basis for the ASTM and CSA Standards that govern the manufacture of concrete pipe. ASTM C76 & C76M (CSA A-257.2 M) lists design tables for 5 Classes of reinforced concrete pipe (i.e. 40-D through 140-D) showing the pipe diameter, wall thickness, compressive strength of concrete and the amount of circumferential reinforcement required for each class. The steel areas listed are typically minimum required if designed by C76 specifications, however, the overriding acceptance factor is normally the three-edge-bearing test. For some larger pipe sizes where the ASTM & CSA Standards do not list steel areas, the pipe manufacturer may employ the indirect design method as a guide to selecting steel areas. As an alternate to the designs requiring both inner and outer circular cages, the reinforcement may be positioned and proportioned with combinations of circular cages, elliptical cages and quadrant steel mats within the minimum limits specified. Figure 2 illustrates a typical reinforcement pattern for large diameter pipe combining an inner and outer cage with an elliptical cage for optimum positioning of tensile steel.

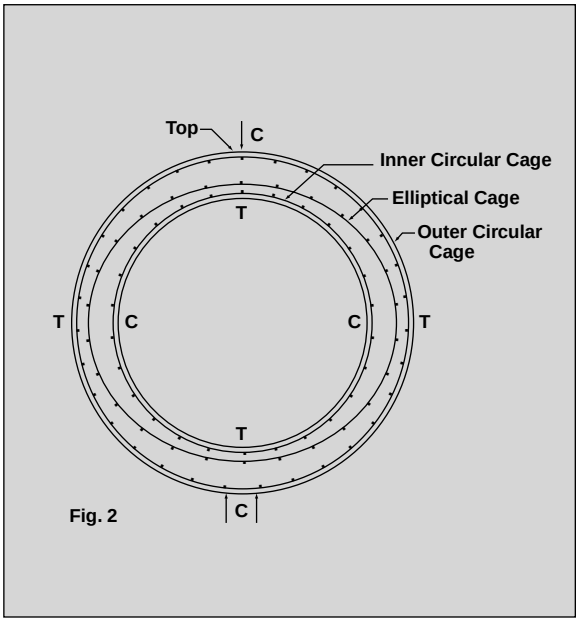


Fig. 2

Steel Reinforcement

Circular reinforcing wire cages are fabricated from pre-manufactured welded wire reinforcement which is rolled or rerolled into the required cage diameter and tack welded. The wire used in pipe fabric is produced from controlled-quality, low carbon hot rolled steel rods. These rods are cold worked through a series of dies to reduce the rod diameter to the specified wire diameter, thus increasing the overall strength of the steel. A deformation roll is added to produce deformed wire. Chemical composition is carefully selected to give proper welding characteristics in addition to desired mechanical properties. Welded wire reinforcement is produced on automatic welding machines which are designed for long, continuous operation. Longitudinal wires are straightened and fed continously through the machine. Transverse wires, entering from the side or from above the welder, are resistance welded to the longitudinal wires each time the longitudinal wires advance through the machine. Wire and welded wire pipe fabric reinforcement is tested in strict conformance with ASTM A370 requirements.

Wire Size Designation

Individual wire (plain and deformed) size designations are based on the cross-sectional area of a given wire. The "W" prefix designates plain wire and "D" designates deformed. The number following the letter gives the cross-sectional area of the wire (for customary units, in hundredths of a square inch). For example, W4 would indicate a plain wire with a cross-sectional area of 0.04 in^2. D4 would indicate a deformed wire with an area of 0.04 in^2. When describing metric welded wire a prefix "M" is added with the number following the letters "MW" or "MD" denoting the steel area in mm^2. For example MW or MD26 refers to an area of 26 mm^2. The enclosed pipe fabric Table 4 lists typical W and equivalent MW wire sizes along with wire areas, diameters & mass (weight) per unit length of wire.

Designating Style Of Welded Wire Reinforcement

Spacings and sizes of wires in welded wire reinforcement are identified by "style". A typical style designation is 2x8 - W12xW5. Here is a description of the numbers in the style:

- Spacing of longitudinal wire = 2" (51 mm)
- Spacing of transverse wires = 8" (203 mm)
- Size of longitudinal wires = W12 size (77 mm^2)
- Size of transverse wires = W5 size(32 mm^2)

The equivalent metric (call out) designation would be 51x203 - MW77xMW32. Note both wire spacings and wire sizes are soft metricated, then rounded to whole numbers.

Calculating Weights (Mass) from Actual Wire Dimensions

When figuring widths, lengths and weights of pipe fabric use the actual metric soft conversions for wire spacings and sizes in Table 4. Due to the approximation of conversion factors and multipliers, when soft converting from metric styles to inch-pound styles or vice versa, calculated weights (mass) and areas of finished products, e.g., rolls and sheets, may vary by as much as 1%. Where there is a variance, the inch pound calculations govern. An example follows:

Inch-pound Style	Metric (call-out) Style	Metric (Actual) Style
2x8 - W12xW5	51x203 - MW77xMW32	50.8x203.2 - MW77.4xMW32.3

Consider the following inch-pound call-out width and length for calculating weights (mass) in this example:

width = 92" + 1/2" + 1/2" overhangs (2337mm + 13mm + 13mm overhangs)
length = 600 feet including 4" overhangs (183m incl. 102mm overhangs)

When figuring weights (mass) of total products, e.g., rolls or sheets use actual (soft converted) wire spacings and sizes, width and length.

Example:	**Wire Size**	**Mass (kg/m)**	**No. of Wires**	**Length (L) or Overall Width (OW)**	**Total Mass**
Long. wires (circumferential)	**MW77.4**	**.607**	**x** $\frac{2336.8}{50.8}$ = 46 spc. (47 wires)	**x L=182.88m**	**= 5217.38**
Cross Wires (longitudinal)	**MW32.3**	**.253**	**x** $\frac{18288}{203.2}$ = 900	**x OW=2.36m**	**=** $\frac{537.37}{5754.75}$ **kg/roll**

Specifications

Welded wire reinforcement and wire for the manufacture of pipe fabric is produced in accordance to ASTM and CSA specifications as listed in Table 1. You will note that plain and deformed welded wire reinforcement have a minimum yield strength equal to 450MPa (65ksi) and 485 MPa (70ksi), respectively. Higher yield strengths, improved weldability, pre-manufactured quality control and fabricating efficiencies are the primary advantages of welded wire reinforcement.

Table 1
Specifications Covering Welded Wire Reinforcement

U.S. Specification	Canadian Specification	Title*
ASTM A 82	CSA G 30.3	Steel Wire, Plain, For Concrete Reinforcement
ASTM A 185	CSA G 30.5	Steel Welded Wire Fabric, Plain, For Concrete Reinforcement
ASTM A 496	CSA G 30.14	Steel Wire, Deformed, For Concrete Reinforcement
ASTM A 497	CSA G 30.15	Steel Welded Wire Fabric, Deformed, For Concrete Reinforcement

Information Tables 2, 3 and 4

See Tables 2, 3 and 4 for load/force conversion factors, a common list of typical wire spacings converted to metric dimensions and a table on properties of wire for welded wire reinforcement for pipe fabric.

Table 2
Length, Area, Mass and Load/Force Conversion Factors or Multipliers

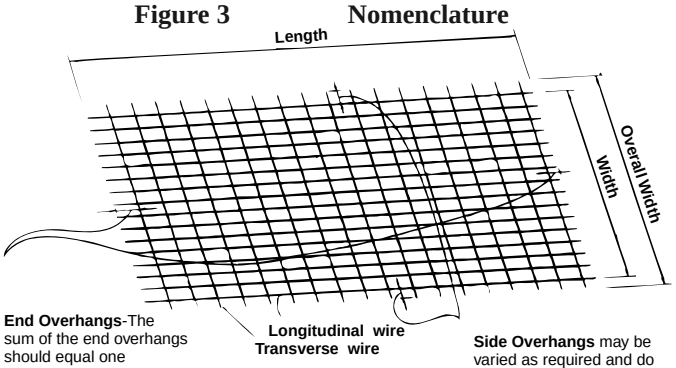
From	X	To
inches	25.4	mm
feet	0.3048	meters
in^2	645	mm^2
in^2/foot	2116.7	mm^2/meter
lbs/ft^2	4.882	kg/m^2
lbs	0.45359	kg
in^2(area)	3.4	lbs/foot(weight)
lbs/ft(weight)	1.488	kg/m(mass)
mm^2(area)	0.007849	kg/m(mass)
lbs(force)	4.448	N(Newtons)
lbs/lin. feet (plf)	14.5931	N/m(Newtons/meter)
lbs/in^2	0.006897	MPa(mega Pascals)

Table 3
Common Pipe Fabric Wire Spacings

Inches	Actual Spacing mm*	Call-out Spacing
2	50.8	51
3	76.2	76
6	152.4	152
8	203.2	203

*When figuring weights (mass) use actual wire spacing dimension and actual wire sizes from Table 4.

Figure 3 Nomenclature



End Overhangs-The sum of the end overhangs should equal one transverse wire space. Unless otherwise specified, each end overhang equals one-half of a transverse space.

Side Overhangs may be varied as required and do not need to be equal. Overhang lengths limited only by overall sheet width.

Industry Method of Designating Style:
Example - 51x203-MW77xMW32 (2x8 W12xW5)

Longitudinal wire spacing
Transverse wire spacing
Longitudinal wire size
Transverse wire size

*(referred in the concrete pipe industry as circumferential wire)
†(referred in the concrete pipe industry as longitudinal wire)

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

PIPE FABRIC

Table 4

Metric Wire Areas, Diameters & Mass With Equivalent Inch-Pound Units[3]

Metric Units[1]				Inch-Pound Units[2]			
Call-out Size[4] (MW=Plain) (mm^2)	Actual size or Area (mm^2)	Diameter (mm)	Mass (kg/m)	Actual Size[4] Area (W=Plain) (in^2x100)	Diameter (in)	Weight (lbs./ft.)	Gage Guide
MW122	122	12.46	.958	W19	.491	.643	7/0
MW116	116	12.17	.910	W18	.479	.612	6/0
MW103	103	11.46	.809	W16	.451	.544	5/0
MW90	90.3	10.72	.708	W14	.422	.476	
MW84	83.9	10.33	.658	W13	.407	.442	4/0
MW77	77.4	9.93	.607	W12	.391	.408	
MW74	74.4	9.73	.583	W11.5	.383	.391	
MW71	71.0	9.50	.556	W11	.374	.374	
MW68	67.9	9.30	.533	W10.5	.366	.357	3/0
MW65	64.5	9.07	.506	W10	.357	.340	
MW62	61.3	8.84	.481	W9.5	.348	.323	
MW58	58.1	8.59	.456	W9	.339	.306	2/0
MW55	54.9	8.36	.430	W8.5	.329	.289	
MW52	51.6	8.10	.405	W8.0	.319	.272	
MW48	48.4	7.85	.379	W7.5	.309	.255	1/0
MW45	45.2	7.60	.354	W7.0	.299	.238	
MW42	42.1	7.32	.329	W6.5	.288	.221	1
MW39	38.7	7.01	.304	W6.0	.276	.204	
MW36	35.5	6.73	.278	W5.5	.265	.187	2
MW32	32.3	6.40	.253	W5.0	.252	.170	3
MW29	28.9	6.07	.228	W4.5	.239	.153	
MW26	25.8	5.74	.202	W4.0	.226	.136	4
MW23	22.6	5.36	.177	W3.5	.211	.119	
MW19	19.4	4.97	.152	W3.0	.195	.102	6
MW16	16.2	4.54	.126	W2.5	.178	.085	8
MW13	12.9	4.05	.101	W2.0	.160	.068	
MW11	11.3	3.79	.089	W1.75	.149	.059	10

[1]Metric wire sizes can be specified in 1 mm^2 increments.
[2]Inch-pound sizes can be specified in 0.001 in^2 increments.
[3] -For other available wire sizes, consult other WRI publications or discuss with welded wire reinforcement manufacturers.
[4] -Wires may be deformed, use prefix MD or D.
Note I -Pipe fabric is provided in rolls or coils, but may be made in sheets

SECTIONAL AREAS OF WELDED WIRE FABRIC
Metric Units1

Call-out Size MW=Plain4	Actual Size or Area3	NOMINAL DIAMETER	NOMINAL MASS	A_s - mm² PER METER				
mm²	mm²	mm	kg/m	51	76	102	152	203
MW122	122	12.46	0.958	2392	1605	1196	803	601
MW 116	116	12.16	0.910	2275	1526	1137	763	571
MW 103	103	11.46	0.809	2020	1355	1010	678	507
MW 90	90.3	10.72	0.708	1771	1188	885	594	445
MW 84	83.9	10.33	0.658	1645	1104	823	552	413
MW 77	77.4	9.93	0.607	1518	1018	759	509	381
MW 74	74.4	9.73	0.583	1459	979	729	489	366
MW 71	71.0	9.50	0.556	1392	934	696	467	350
MW 68	67.9	9.30	0.533	1331	893	666	447	334
MW 65	64.5	9.07	0.506	1265	849	632	424	318
MW 62	61.3	8.84	0.481	1202	807	601	403	302
MW 58	58.1	8.59	0.456	1139	764	570	382	286
MW 55	54.9	8.36	0.430	1076	722	538	361	270
MW 52	51.6	8.10	0.405	1012	679	506	339	254
MW 48	48.4	7.85	0.379	949	637	475	318	238
MW 45	45.2	7.60	0.354	886	595	443	297	223
MW 42	42.1	7.32	0.329	825	554	413	277	207
MW 39	38.7	7.01	0.304	759	509	379	255	191
MW 36	35.5	6.73	0.278	696	467	348	234	175
MW 32	32.3	6.40	0.253	633	425	317	213	159
MW 29	28.9	6.07	0.228	567	380	283	190	142
MW 26	25.8	5.74	0.202	506	339	253	170	127
MW 23	22.6	5.36	0.177	443	297	222	149	111
MW 19	19.4	4.97	0.152	380	255	190	128	96
MW 16	16.2	4.54	0.126	318	213	159	107	80
MW 13	12.9	4.05	0.101	253	170	126	85	64
MW 11	11.3	3.79	0.089	222	149	111	74	56

[1]Metric wire sizes can be specified in 1 mm² increments.
[2]Inch-pound sizes can be specified in 0.001 in² increments.
[3]For other available wire sizes, consult other WRI publications or discuss with welded wire reinforcement manufacturers.
[4]Wires may be deformed, use prefix MD.
Note - Pipe fabric is provided in rolls or coils, but may be made in sheets.

SECTIONAL AREAS OF WELDED WIRE REINFORCEMENT nch-pound Units2

ACTUAL WIRE SIZE3 OR AREA W = PLAIN4	NOMINAL DIAMETER	NOMINAL WEIGHT	A_s - SQ. IN PER LINEAR FT. CENTER TO CENTER SPACING				
(in2 x 100)	in	lbs./lin. ft.	2"	3"	4"	6"	8"
W19	0.491	0.643	1.13	0.76	0.57	0.38	0.28
W18	0.479	0.612	1.08	0.72	0.54	0.36	0.27
W16	0.451	0.544	0.96	0.64	0.48	0.32	0.24
W14	0.422	0.476	0.84	0.56	0.42	0.28	0.21
W13	0.407	0.442	0.78	0.52	0.39	0.26	0.195
W12	0.391	0.408	0.72	0.48	0.36	0.24	0.18
W11.5	0.383	0.391	0.69	0.46	0.345	0.23	0.173
W11	0.374	0.374	0.66	0.44	0.33	0.22	0.165
W10.5	0.366	0.357	0.63	0.42	0.315	0.21	0.157
W10	0.357	0.340	0.60	0.40	0.30	0.20	0.15
W9.5	0.348	0.323	0.57	0.38	0.285	0.19	0.142
W9	0.339	0.306	0.54	0.36	0.27	0.18	0.135
W8.5	0.329	0.289	0.51	0.34	0.255	0.17	0.127
W8	0.319	0.272	0.48	0.32	0.24	0.16	0.12
W7.5	0.309	0.255	0.45	0.30	0.225	0.15	0.113
W7	0.299	0.238	0.42	0.28	0.21	0.14	0.105
W6.5	0.288	0.221	0.39	0.26	0.195	0.13	0.098
W6	0.276	0.204	0.36	0.24	0.18	0.12	0.09
W5.5	0.265	0.187	0.33	0.22	0.165	0.11	0.083
W5	0.252	0.170	0.30	0.20	0.15	0.10	0.075
W4.5	0.239	0.153	0.27	0.18	0.135	0.09	0.068
W4	0.226	0.136	0.24	0.16	0.12	0.08	0.06
W3.5	0.211	0.119	0.21	0.14	0.105	0.07	0.053
W3	0.195	0.102	0.18	0.12	0.09	0.06	0.045
W2.5	0.178	0.085	0.15	0.10	0.075	0.05	0.038
W2	0.160	0.068	0.12	0.08	0.06	0.04	0.03
W1.75	0.149	0.059	0.105	0.07	0.053	0.035	0.026

[1]Metric wire sizes can be specified in 1 mm2 increments.
[2]Inch-pound sizes can be specified in 0.001 in2 increments.
[3]For other available wire sizes, consult other WRI publications or discuss with welded wire reinforcement manufacturers.
[4]Wires may be deformed, use prefix D.
Note Pipe fabric is provided in rolls or coils, but may be made in sheets.