

How to Specify, Order & Use Welded Wire Reinforcement In Light Construction

Welded Wire Reinforcement (WWR)

Widely Used

Literally millions of square feet of residential slabs, driveways, sidewalks, patios and slabs for light construction are reinforced with welded wire reinforcement (WWR). Welded wire reinforcement must be properly placed if it is to perform effectively. This publication will briefly discuss the reasons for using welded wire reinforcement, its benefits and how to place it properly.

WWR Used To Control Cracking

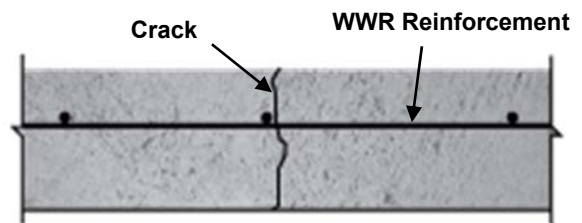
Concrete by its very nature tends to crack. In residential and light construction, cracking is due primarily to drying shrinkage, temperature and moisture changes, weak subgrades and sometimes poor quality concrete. Steps can be taken to reduce cracking while other procedures control cracking. **The primary purpose of welded wire reinforcement in slabs is to control cracking and crack widths in both directions.** Welded wire reinforcement keeps the cracked sections of a slab closely knit together so that the slab will act as a unit.

WWR Helps Aggregate Interlock

When a slab cracks, the faces within the crack are jagged. If the sections on each side of the crack are held closely together, the jagged faces of the concrete are interlocked which helps transfer loads across the crack. This factor is called aggregate interlock. As the crack becomes wider the interlock between the faces of the crack decreases and becomes less effective. In residential and light construction, aggregate interlock is usually ineffective when the crack width exceeds 1/16 in. (0.06"). Welded wire reinforcement holds the cracks closely together so that aggregate interlock will function properly. Closely knit cracks are also less noticeable, and they minimize the movement of water through the slabs at cracks.

Some Thoughts for Builders about Welded Wire Reinforcement

Probably every builder has at one time or another said; "If I eliminate the welded wire reinforcement, I'll save some money," or someone might have said, "Take out the WWR and add another inch of concrete, it's cheaper." Someone else might have said, "The stuff stays down on the bottom and doesn't do much good." Let's critically look at these statements.



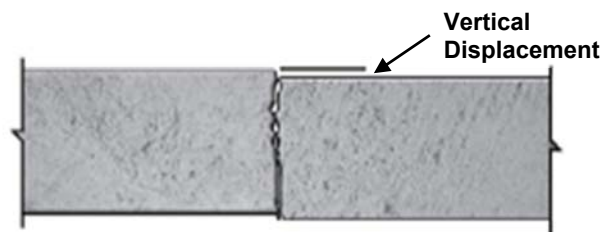
Reinforced Slab

WWR holds slab closely together across crack so that cracked sections remain interlocked and the slab acts as a unit. This action is known as "aggregate interlock"



Unreinforced Slab

As a crack widens, aggregate interlock becomes less effective. When cracks reach 1/16 inch or more in width, aggregate interlock is usually no longer effective. Wide cracks are also extremely noticeable.



Vertical displacement is the difference in elevation between two cracked sections of a slab. It is one of H.O.W.'s criteria on concrete slabs.

Proper Placement is Essential

Welded wire reinforcement should be placed in the middle one third of a 4 to 6 inch thick concrete slab or driveway. WWR, partially buried in the subgrade, has little value. The reinforcement should be placed to reinforce the concrete, not the subgrade. **When welded wire reinforcement is properly placed, it does its job and does it well.**

Thicker Slabs vs. Reinforcement

This argument frequently arises but it overlooks three key points about cracking:

- Most cracks formed in residential and light construction are due to drying shrinkage and temperature changes.
- Both four and five inch slabs will contract the same amount due to drying shrinkage, and will contract equally as the temperature drops.
- Thickening the slab does not change shrinkage and temperature contraction and reinforcement is still needed.

The material cost of reinforcement is almost always less than the material cost of extra concrete. As a matter of fact, the “in-place” cost of welded wire reinforcement may be less than the material cost of an extra inch of concrete and the WWR reinforces the entire slab. For example, the material cost of an inch of concrete per square foot is \$0.15-0.18 when concrete reinforcement used is small. Two widely used styles of reinforcement used in residential and light construction are 6x6 W1.4 x W1.4 (10 gauge) and 6x6 W2.9 x W2.9 (6 gauge). These sheets of WWR only weigh 0.21 lb and 0.42 lb per square foot respectively. We suggest that you compare total costs. A reinforced slab may cost the same or less than a slightly thicker unreinforced slab and there is a difference.

Some Additional Reasons to Use WWR

The main purpose of reinforcement is crack control. Crack control is important in a residence. A home is generally a family’s largest investment and is a source of great pride. Concrete slabs with cracks or uneven surfaces are a matter of no little concern to homeowners. The proper placement of welded wire reinforcement in slabs will go a long way in reducing this concern.

WWR Reinforcement will:

- Improve performance of concrete work which means higher owner satisfaction.
- Reduce or even eliminate callbacks for repairs by dissatisfied customers.
- Make compliance with NAHB’s Home Owners Warranty (H.O.W.) provisions easier because of improved crack control. H.O.W. requires repairs when cracks exceed limits of H.O.W.’s Performance Standards (see Table 1).

- Require fewer joints. The only practical way to control cracking in plain concrete is to use joints at very close intervals – generally less than 15ft. apart. Joints are acceptable in sidewalks and driveways. Joints are not particularly desirable in floor slabs, porches, carports and garages. Welded wire reinforcement reduces the need for many joints in these slabs.

Table 1
*** Provisions Home Owners Warranty Program on Cracking of Concrete**

	Performance Standard	
	Maximum Permissible Crack Width	Maximum Permissible Crack Width
C.I.P. basement walls	1/8"	–
Basement floors	3/16"	*1/8"
Attached garage slabs	1/4"	1/4"
Stoops and steps	Hairline only (less 1/16")	–
Patios	1/4"	1/4"
Slab-on-grade	Any crack which significantly impairs appearance or performance of the finish flooring material is not acceptable.	

* Published by Home Owners Warranty Corporation, National Housing Center, Washington, D.C. 20005

Proper Placement

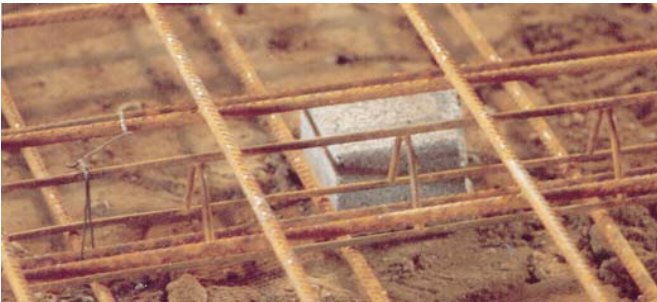
The proper placement of welded wire reinforcement is relatively simple and inexpensive. There is no acceptable reason for its improper placement. Welded wire reinforcement should be placed in the middle third of 4 to 6 inch slabs. Two inches below the surface is recommended in most cases.

The most common ways of placing WWR are:

- (1) chairing WWR,
- (1) placing concrete in two courses and placing WWR on the first course.

Table 2
Proper Location of WWR in Slab

Slab Thickness	Location of WWR
4"	Middle of Slab
5"	2" below top surface
6"	2" below top surface



Various supports for welded wire reinforcement. Place supports 2-3 feet apart for proper positioning of welded wire reinforcement during concrete placing. Concrete block, wire or plastic supports to hold reinforcement. These units are economical and effective.

Chairs or concrete blocks cost very little. Reinforcement is placed in a slab primarily to control cracking. When considering the cost of concrete, reinforcement, and vapor barriers, the cost ensuring proper placement is a small, but important, part. Properly placed WWR can make a tremendous difference in slab performance—and for only cents per square foot. Depressing or “walking-in” WWR and “hooking” WWR are not methods of placement. **Neither method is considered accurate for proper placement.**

Chairing WWR

The most widely used method is to chair or support WWR. A number of concrete accessory suppliers sell chairs and supports for this purpose. The supports are usually steel wires or plastic units and should have a solid base so they will not sink into the subgrade or subbase. Base plates are particularly important when a sand subbase is placed over the subgrade. The chair or support should not puncture the vapor barrier if one is used. Small concrete blocks with an imbedded wire or grooved on top are used for supports and require no base plates. These are the most economical and effective way to bolster welded wire reinforcement for slabs on grade. A very simple chair or support is simply a piece of concrete 2 or 3 inches thick and about 4 x 4 inches square. Many other styles of supports are available and effective.

The important part is the use of support to achieve proper placement within the slab. The spacing will depend upon the wire size and the wire spacing. Common practice is to place supports 2 to 3 feet apart.

Placing WWR in Two-Course Work

This is usually the most effective way of placing WWR. It does require more time. The first course of concrete is placed generally to mid-depth or perhaps slightly more. The WWR is then placed and the second course should be placed before the lower course

starts to harden to prevent formation of a “cold” joint between the courses.

STYLE OF WWR TO USE

Slab thickness and the distance between walls or design joints primarily determine the style of WWR to use. Thus as slabs become longer (or thicker) they require heavier WWR.

Minimum Reinforcement Determined (As developed by the traditional subgrade drag method used in slab and pavement design)*

Table 3 gives the Minimum Reinforcement for 4-Inch Thick Lightly Reinforced Slabs-on-Ground. The maximum dimensions in Table 4 refer to the distance between design joints, between walls or between a joint and a wall.

* Subgrade drag theory is explained on page 21 of the Portland Cement Association publication entitled “Concrete Floors on Ground”, Second Edition.

Intermediate Control Joints

Intermediate control (or contraction) joints can be formed or sawcut in concrete reinforced with WWR for additional crack control. Sidewalks and driveways which are sometimes quite long should have control joints. The WWR continues across the control joint and is very helpful in the control of vertical displacement due to the dowelling action of the WWR. For heavier styles of WWR it may be necessary to cut 1/3 to 1/2 of the wires to guarantee full depth crack control.

Table 3
Requirements for 4-Inch Thick Lightly Reinforced Slab-On-Ground

Maximum Dimension	Style Of WWR
Up to 35 ft.	6 x 6 W1.4 x W1.4
36 ft. to 45 ft.	6 x 6 W2.0 x W2.0
46 ft. to 60 ft.	6 x 6 W2.5 x W2.5
61 ft. to 75 ft.	6 x 6 W2.9 x W2.9 or 6 x 6 W3.0 x W3.0
76 ft. to 100 ft.	6 x 6 W4.0 x W4.0

Table 4
Common Styles of Welded Wire Reinforcement

Style Designation		Steel Area Sq. In. Per Ft. -		Weight Approx. Lbs. Per 100 S.F.
New Designation (by W- Number)	Old Designation (by Steel Wire Gauge)	Longit.	Tran.	
6X6 - W1.4xW1.4	6 x 6 - 10 x 10	.028	.28	21
6X6 - W2 x W2	6 x 6 - 8 x 8	.040	.040	29
6X6 - W2.9xW2.9	6 x 6 - 8 x 8	.058	.058	42
6X6 - W4xW4	6 x 6 - 4 x 4	.080	.080	58
4X4 - W1.4xW1.4	4 x 4 - 10 x 10	.042	.042	31
4X4 - W2xW2	4 x 4 - 8 x 8	.060	.060	43

How to Specify and Order Welded Wire Reinforcement

Welded wire reinforcement is a prefabricated reinforcing material, and thus the method of specifying and ordering it is different from other types of reinforcement. It is available in both rolls and sheets. Some styles of WWR are commonly stocked by WWR producers, supply houses, distributors and fabricators. Table 4 lists many of the commonly stocked items.

WWR is sold in rolls or sheets. Roll width varies in the area where it is sold and is generally 5 to 7 ft. Roll length is normally 150 or 200 ft. Rolls or sheets are easy to haul and store.

The biggest advantage of sheets is the fact that there is no need to unroll and straighten the WWR. Sheets are thus easier to place and give better placement control. Sheets are commonly 5 to 10 feet wide and 10 to 20 feet long. Also, 25 foot sheet lengths are common and available from stock in the Western, USA. Other sizes are available. In other instances, WWR is produced specifically for an individual job or project.

When specifying non-stock items, the volume must be sufficient to justify production at an economical cost. In many instances the WWR producer must draw wire to produce special orders. In addition, the machine must be stopped and the wires changed for the next order of WWR. Quantity requirements vary with different producers.

Generally, a minimum quantity of 40,000 lb. is required to produce a special order involving a major change, such as a change in longitudinal wire size or spacing. The minimum

quantity on minor changes involving the same size longitudinal wire is considerably less. Minor changes might be a change in size or spacing of transverse wires, length of side or end overhangs, or length changes.

The production of WWR has a facet similar to precast production or the use of forms in cast-in-place work – the greater the repetition the less the cost. It is therefore urged that a minimal number of styles be used for maximum economy, thus saving on the cost of WWR. Equally important, fewer styles reduce on-site or in-plant costs, since there are fewer pieces to inventory and handle, ensuring quality control.

Table 5
Specifications Covering WWR

U.S. Specification	Canadian Standard	Title
ASTM A 82	CSA G 30.3	Cold-Drawn Steel Wire for Concrete Reinforcement
ASTM A 185	CSA G 30.5	Welded Steel Wire Reinforcement for Concrete
ASTM A 496	CSA G 30.14	Deformed Steel Wire for Concrete Reinforcement
ASTM A 497	CSA G 30.15	Welded Deformed Steel Wire Reinforcement for Concrete

*The Titles of the ASTM Specifications and CSA Standards are identical

Specifications

The American Society for Testing and Materials publishes specifications for the wire used to manufacture WWR for both smooth and deformed welded wire reinforcement. The Canadian Standards Association publishes similar standards for use in Canada. The corresponding titles and numbers are given in Table 5. These are considered to be the governing specifications for both wire and welded wire reinforcement.

Some governmental agencies have special specifications which will control if cited.

Minimum Strengths

Welded wire reinforcement is a high strength reinforcement material. The minimum yield strength for smooth welded wire reinforcement is 65,000 psi.

The minimum yield strength of deformed welded wire reinforcement is 70,000 psi. Higher yield strengths up to 80,000 psi are available. See Table 6 for minimum properties of steel wire.

Table 6
ASTM and CSA Minimum Properties of Steel Wires in Welded Wire Reinforcement

Type of WWR	Min. Tensile Strength (psi)	Min. Yield Strength (psi)	Weld Shear Strength
Welded Plain Wire Reinforcement	75,000	65,000	35,000
Welded Deformed Wire Reinforcement	80,000	70,000	35,000

*Yield strength is measured at 0.005 inch per inch extension of gage length

Welded Smooth Wire Reinforcement

There are two types of wire, plain (or smooth) and deformed. Plain WWR develops anchorage of the steel at the welded intersections. In plain WWR the smaller wire should have a cross-sectional area equal to at least 40 percent of the area of the larger wire. ASTM specifies a weld shear strength of 35,000 psi times the area of the larger wire.

Welded Deformed Wire Reinforcement

Deformed wire has two or more lines of deformations along the wire depending on the size of the wire. Anchorage is developed along the wire by virtue of the deformations and at the welded intersections. In deformed WWR the smaller wire should have at least 40 percent of the cross-sectional area of the larger wire. The weld shear strength for deformed WWR is 35,000 psi times the area of the larger wire.

Wire Size Designation

In 1970 ASTM changed from the gauge system to a more

rational numbering system which relates to the cross-sectional area of the wire. The new numbering system was designed to simplify the use of welded wire reinforcement. The designation of wire sizes by gauges gives no pertinent information such as diameter or cross-sectional area. In addition, the cross-sectional area of most gauges are given in complex numbers. i.e., 2 gauge=0.054sq. in., 2/0 gauge=0.086 sq. in. (both in cross-sectional areas). It is also difficult to relate gauges and cross-sectional areas, and this often requires frequent reference to tables.

The current system involves a letter-number combination. ASTM uses the letter “W” to designate smooth wire and the letter “D” to designate deformed wire. The number following the letters “W” or “D” gives the cross sectional area of the wire in hundredths of a square inch. For instance, a W5.0 is a smooth wire with a cross-sectional area of 0.05 sq. in. A W5.7 wire has a cross-sectional area of 0.057 sq. in. D6.0 would indicate a deformed wire with a cross-sectional area of 0.06 sq. in. WWR should be specified using the “W” or “D” numbers designation rather than gauge number. Table 7 gives a comparison between the gauges and the “W” and “D” numbers. There are four widely used styles of WWR namely 4-, 6-, 8-, and 10-gauge.

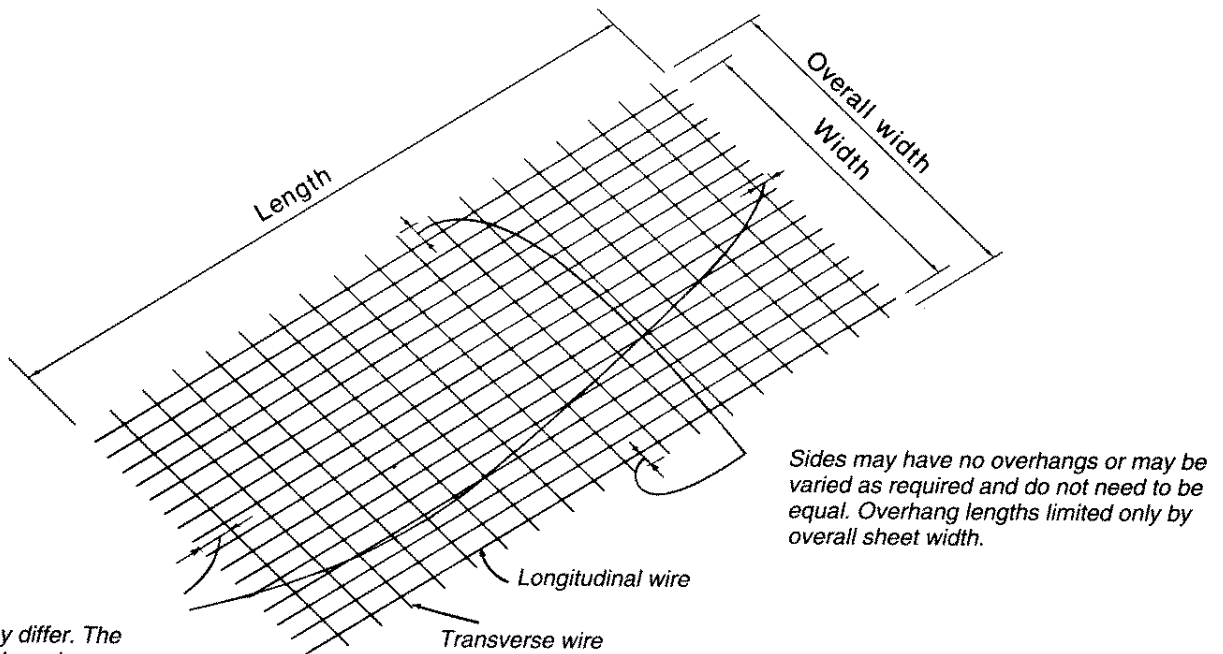
Their corresponding W-numbers for plain WWR are:

- 4 gauge equals W4.0 6 gauge equals W2.9
- 8 gauge equals W2.1 10 gauge equals W1.4

It is preferred that these wires be ordered by the proper W-number. The current numbering system makes it extremely easy for the designer. For instance, if a steel cross-sectional area of 0.15 sq. in. per lin. ft. is needed, it can be met with W5 wires on 4-in. centers (3 wires pr lin. ft. each with a cross-sectional area of 0.05 sq. in.).

Example of Typical Order

Item	Quantity	Style	Width	Side Overhangs	Overall Width	Length
1	1000 Sheets	6x12 - W12xW5	96"	(+0", +0")	96	20' - 0"
2	150 Rolls	6x6 - W2xW2	96"	(+0", +0")	96	150' - 0"
3	500 Sheets	4x8 - D10xD4	76"	(+2", +6")	84	17' - 4"



End overhangs may differ. The Sum of the two end overhangs, however, should equal the transverse wire spacing.

Designating Style of WWR

Welded wire reinforcement is designated by two numbers and two letter-number combinations. An example is 6x8 – W8 x W4. The first number gives the spacing in inches of the longitudinal wires. The second number gives the spacing of the transverse wires in inches. The first letter-number combination gives the type and size of the longitudinal wire, and the second combination gives information on the transverse wire. Thus, in the above example the longitudinal wires are 6 in. apart while the transverse wires are 8 in. apart. The longitudinal wire is plain and has a cross-sectional area of 0.08 sq. in. while the transverse wire is also plain and has an area of 0.04 sq. in.

Longitudinal wire spacings vary. Typical spacings are 2,3,4,6,8,12,16,18, and 24 in. The concrete pipe uses considerable welded wire reinforcement with 2 in. and 3 in. spacings. Most building, paving and structural reinforcement have 4 in. through 18 in. longitudinal wire spacings.

Transverse wire spacings are normally 4,6,8,12, 16 and 18 in. It is possible to order other wire spacings but these will normally cover most situations.

Other Dimensions

End overhangs, unless otherwise specified, are one-half of the transverse wire spacing, For instance, a 6x6 reinforcement would have a 3 in. overhang on each end. Specific lengths of end overhangs can be specified.

However, the sum of both end overhangs should equal the transverse wire spacing. The length of a WWR roll or sheet is the tip-to-tip length and includes the end overhangs. Length is usually expressed in feet.

Side overhangs will not be furnished unless specified. ASTM does permit an overhang up to 1 inch on each side. An example of how to specify a side overhang might be +1 +3 designation which indicates a 1 inch overhang on one side and a 3 inch overhang on the opposite side. The width of WWR is the center-to-center distance between the outside longitudinal wires and is expressed in inches. The overall width includes side overhangs and is the tip-to-tip length of the transverse wires.

Information on Ordering

Certain information is needed when ordering. The example on this page illustrates how a typical order of welded wire reinforcement might appear using the nomenclature described.

Calculating Weights

The calculation of welded wire reinforcement weights is relatively simple. Use the following formula to find weight of both longitudinal and transverse wires.

$$\text{wt-number wires} \times \text{length in feet} \times \text{area of wire in sq. in.} \times 3.4$$

$$\text{*No. of longitudinal wires} = \frac{(\text{width, in.}) + 1}{\text{longitudinal wire spacing, in.}}$$

$$\text{*No. of transverse wires} = \frac{\text{length, in.}}{\text{transverse wire spacing, in.}}$$

When using sheets, it is often easier to determine weight of sheet and then convert to weight per 100 sq. ft.

For example, what is weight of 8 x 20 ft. sheets of 6x12-W12xW5 with no side overhangs.

Longitudinal wires:
 20 transverse wires
 x 8 ft. x 0.05 x 3.4 = 27.2 lb.
 Weight of sheets = 165.9 lb.

Weight per 100 sq. ft. = 100/8x20 x wt. sheet
 Weight of 165.9 = 103.7 lb. per 100 sq. ft.

Concrete Shrinks with Age—A Cause of Cracking

Concrete has its greatest volume when it is first placed in the forms. As it sets, it starts to contract or shrink, The shrinkage process continues for several years. It is estimated, however, that 60% to 70% of the shrinkage will occur by the time the concrete is three to six months old. Shrinkage varies with many factors, such as amount of mixing water and cement used, type of aggregate, humidity and slump. In plain concrete, the drying shrinkage varies from 1/2 to 1 inch per 100 ft. Assuming an average shrinkage of 3/4 in.per 100 ft., a 30' x 60' slab would shrink or contract slightly over 1/5 inch in the 30 ft. dimension, and 0.45 or almost 1/2 inch in the long direction. If a plain (unreinforced) slab is not divided by joints, it will almost always crack. If there are, for instance, only one or two cracks, they may become entirely too wide for satisfactory performance.

Subgrade Settlement and Loads – A Cause of Cracking

The subgrade (or subbase, if one is used) must provide uniform support for the slab. If uniform support is not

provided, loads may cause the slab to crack and one section could drop considerably below the other – a condition referred to as vertical displacement. This problem is often observed in residential work. It is due to two factors – the crack opens too wide for aggregate interlock to act and the support by the subgrade is not uniform causing uneven settlement of the subgrade. Loads such as vehicles on a driveway increase the problem.

The use of sound fill material, careful placement of fill materials and adequate compaction are important. This is especially true of the area over trenches excavated for utility lines. Many builders place a double layer of WWR over the trenched area. This provides additional structural strength. Subgrades inside foundation walls are difficult to fill and compact adequately. Excessive moisture under slabs also reduces support.

The loads on residential and light slabs are usually not heavy enough to cause a problem. Point loads, such as bearing walls or fireplaces, may sometimes necessitate special design. Driveways, garage and carport slabs, and sidewalks where they cross driveways are generally exposed to the severest loads. However, a faulty subgrade or unusual load or the combination of both can cause severe cracking problems.

Temperature Changes Affect Concrete—A Cause of Cracking

As the temperature increases, a slab expands and as the temperature drops, it contracts. Since there is relatively little temperature change within a house, temperature may have little effect on interior slabs. Temperature does, however, affect exterior concrete, such as sidewalks, driveways and porches, carport and patio slabs. The effects of temperature changes must be considered in the construction of garage slabs, unheated buildings and outside flatwork. A drop of 100 degrees F, in temperature will cause a contraction of approximately 2/3 inch per 100 ft. A temperature drop of 50 degrees, F, say from 80 degrees to 30 degrees, will cause a contraction of 1/3 inch per 100 ft.

Drying shrinkage and temperature contraction are independent of each other. If a slab contracts 3/4 inch per 100 ft. from drying shrinkage, it will contract or expand additionally for temperature changes. Thus the total contraction on a cold day is considerable, often causing cracks to open up excessively in unreinforced concrete.

Table 8
**Slab Contraction Due to Drying Shrinkage and
 a Temperature Change of 75 Degrees, F**

	30 ft.	40 ft..	50 ft.	60 ft..	75 ft.	100 ft.
Contraction due to drying shrinkage at rate of 3/4" per 100'	.23"	.30"	.38"	.45"	.56"	.75"
Contraction due to temperature drop of 75° F*	.15"	.20"	.25"	.30"	.37"	.50"
Total contraction	.38"	.50"	.058	.63"	.93"	1.25"

* For 100 ∞ F difference, increase contraction 1/3; for a 50 ∞ difference, subtract 1/3 temperature contraction value.

Summary

The Benefits of Welded Wire Reinforcement Are:

- Holds cracked sections closely together enabling slab to act as a unit through effective aggregate interlock action. Aggregate interlock decreases rapidly as crack width exceeds 1/16 inch.
- Maintains level, even surface so one cracked section will not drop below the other which often happens when a wide crack develops on a weak subgrade.
- Adds some structural strength to slabs although amount of steel is small. The use of WWR will normally reduce number of cracks.
- Permits larger panels and thus fewer joints.
- Improves appearance of slab by holding cracks together.