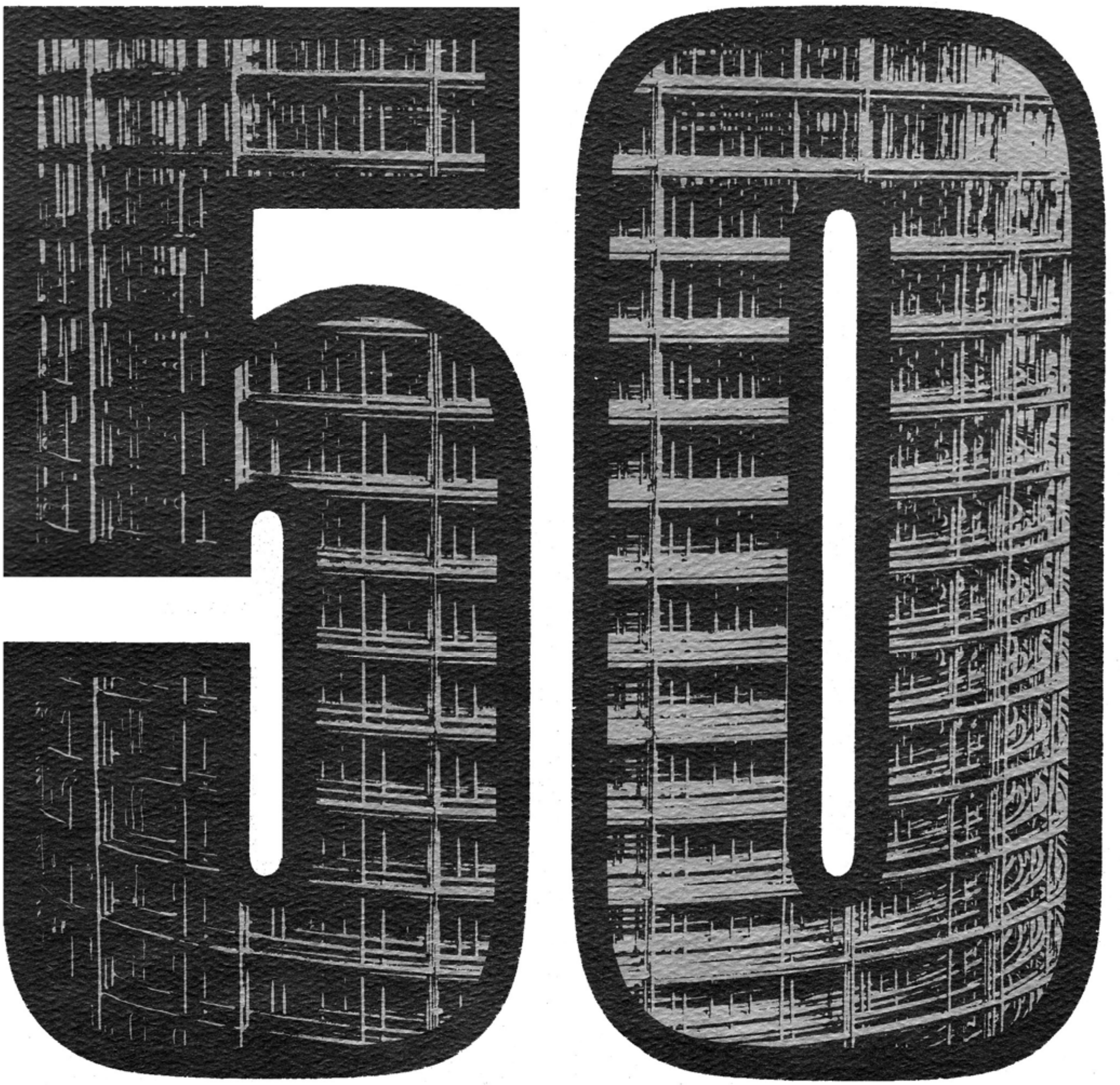
Men of Steel

The Story of Welded Wire Fabric and the Wire Reinforcement Institute

50 Years Old and Growing



WIRE REINFORCEMENT INSTITUTE®

To The Wire Reinforcement Institute and Its Members
A number of Associate Member Companies have sponsored the preparation of a history of WRI. We hereby make a gift of this history to you on the occasion of your 50th anniversary. The following companies participated in this gift:

Bowers-Siemon Chemicals Company
Erin Wire Machinery Limited (BSG)
R.E. Kleinhans, Inc. (EVG)
Korf Industries, Inc.
Mannesmann Pipe and Steel Corp.
R.H. Miller Division/Pennwalt Corp.
Raritan River Steel Company
Superior Concrete Accessories, Inc.
United States Steel Corporation

As associate members, we congratulate the Institute and we are proud to be a part of it. May the next 50 years be equally rewarding.

Neil A. Bowers
Chairman
Associate Member Division Wire Reinforcement Institute

MEN OF STEEL:
The story of Welded Wire Fabric and the Wire Reinforcement Institute

50 years old and growing!

by: Donald M. Gehring

Lambot, Wilkinson, Coignet, Monier, Wayss, Bauchinger, Ward, Ransome, Thomson, Perry. The list is short. They are men from another century. They were pioneers. They started it-reinforced concrete-the most versatile of all building materials.

Pease, Coons, Glose, Schusler, Shepherd, Stewart, Egan, Capouch' were practitioners-the list goes on and is long. They are men of just yesterday and today. They were the men of steel. They took an idea and built an industry and an organization.

The industry is the manufacture of welded wire fabric and other wire reinforcing products. The organization is the Wire Reinforcement Institute. This story concerns the men who made it happen.

This account, then, is dedicated to the founding fathers of reinforced concrete of the last century and to the men of this century who believed in a first-rate reinforcing product, welded wire fabric, who fought for its use and acceptance-and persuaded others to try it. They worked always toward a practical goal, an ever better reinforcing product for a better end product, reinforced concrete.

1 For a more complete listing of the industry’s leaders, past and present, please see the Roll of Honor, on page 2.

A Note About Men and Sources

Not every WRI leader and his contribution could be acknowledged in this account of the past 50 years. The few selected for inclusion were typical of the selfless dedication of the many who were not mentioned. Perusal of the Roll of Honor, however, will afford the reader a broader, more inclusive understanding of the many who contributed to the industry's and the Institute's growth and development.

ROLL OF HONOR

Presidents

1942	Walter H. Stewart'	Truscon
1943	Robert L. Glose*	Pittsburgh
1944-1945	Ford P. Schusler*	Keystone
1946	J.C. Shepherd'	Sheffield
1947	Walter H. Stewart*	Truscon
1948	Alfred B. Egan	Sheffield
1949	M. Edward Capouch	USS
1950	Thomas C. Phillips*	Pittsburgh
1951	Howard J. Davis	CF & I
1952	William F. Kuntemeier*	Laclede
1953	Donald M. Schmid	Truscon
1954	Walter H. Leo	Sheffield
1955	Richard H. Frizzell*	CF &I
1956	Ivy H. Smith	Ivy
1957	Wayne O.Stoughton	Pittsburgh
1958	Earl C. Planett*	Planett
1959	Warren D. Dreher	CF &t
1960	Bruce D. Bennett*	USS
1961	David W. Roberts	Armco
1962	Bankhead C. Warren	Ivy
1963	DeWitt A. Stevenson .	Republic
1964	James L. Walker	Davis Walker
1965	T.L. Griffith	Pittsburgh
1966	F.J. Velde	Keystone
1967	Emerson W. Heisler	USS
1967	L.A. Gray	Stelco
1968	E.F. Anderson	Armco
1969	L.B. Allen	CF & I
1970	W.B. Cies	Northwestern
1971	L.A. Gray	Erin
1972	Arthur Nichols	Texas Steel
1973	Andrew K. Wood	USS
1974	G. Ross French	National Wire
1975	Jack E. Elliott	Penn-Dixie

Chairmen of the Board

1976-1977	Fred E. West	Irving Wire
1978	Robert C. Richardson	Davis Walker
1979	William Y. Longshore	Ivy Steel
1980	H. Steele Price III	Price Brothers

Chairmen, WRI Technical Committee

1946-1950	A. Carl Weber	Laclede
1951-1952	M. Edward Capouch	USS
1953-1954	Richard H. Frizzell*	CF & I
1955	P.J. Callahan	Republic
1956-1957	A.B. Greene	Republic
1957-1958	W.F. Kuntemeier*	Laclede
1959-1960	Wayne O. Stoughton	Pittsburgh
1961-1962	D.A. Stevenson*	Republic
1963	G.W. Bowlby	Stelco
1964-1973	Allan B. Dove	Stelco
1973-1976	Robert D. Bay	Laclede

Managing Directors

1930-1945	Royall D. Bradbury*
1945-1948	Theodore J. Kauer
1948-1968	Frank B. Brown
1968-1971	Henry Aaron
1971-1976	Walter L. Manifold
1976-Date	William V. Wagner, Jr.

'Deceased

Technical Committee per se discharged in 1976. Successor is Codes and Standards Committee and Product Development Committee.

CHAPTER ONE

1850-1900: A New Concept-Reinforced Concrete

The idea of reinforcing concrete, a material which had been around since Roman times, seems to have had its first realization in a small boat, of all things! In 1850 a Frenchman named Lambot built a concrete boat in which iron bars were embedded, presumably for greater strength. It floated. Meanwhile, across the channel an Englishman, W.B. Wilkinson, possibly thinking along similar lines, patented a reinforced concrete floor slab in 1854. Back in France, Joseph Monier, perhaps reflecting on Lambot's boat which had been displayed at the 1855 Paris Exposition, tried reinforcing concrete garden tubs and pots with metal frames. Although a gardener first and an inventor second, he had the foresight to patent his application.

Another Frenchman, Francois Coignet, a contemporary of Monier, went public in 1861 with a treatise on the principles of reinforcement in concrete and the end product's increased resistance to tensile stresses. He, too, obtained a patent in 1869 which described a system of interlacing clamps and hoops in concrete to produce a stronger structure although the thickness of the walls was considerably reduced.

But it remained for two German engineers, Wayss and Bauchinger, to take the concept out of experimentation and into the real world of construction. After an investigation into the Monier approach, they purchased his patent rights and in 1884 published a paper entitled "Das System Monier." Their work probably launched reinforced concrete as a proper material for use in buildings, railroad structures and public works.

Even then, good ideas could cross oceans. In Port Chester, New York, businessman W.E. Ward heard about the "new" material. He was exasperated after having been burned out of three houses. In 1872 he built a new home of reinforced concrete for his family. To demonstrate that it was really fireproof, he lit bonfires on the floors of several rooms! His home was one of the first truly reinforced concrete buildings in the world, and was soon followed by other U.S. structures in which E.L. Ransome used hoop iron and wire rope as reinforcement. By the turn of the century, the use of reinforced concrete in building construction was accepted although not common.

About the same time, serendipity played a part in setting the stage for welded wire fabric. In 1885, Elihu Thomson was experimenting with a spark coil and a bank of batteries when the flow of current across the narrow gap between two 1/4-inch steel rods fused their tips together. Thomson realized the importance and sensed the commercial possibilities of his discovery. Thomson, who later became President of Massachusetts Institute of Technology, extended his work which eventually resulted in the development of the widely used resistance welder, a key element in the production of welded wire fabric.

CHAPTER TWO

1900-1925: A Product Becomes Accepted

The next link in the chain of happy accidents leading to welded wire fabric was forged in Clinton, Massachusetts, where, in 1901, inventor John C. Perry filed patent papers on a machine to make wire fencing. His machine employed Thomson's resistance welding principle to fuse continuous lengths of wire to cross wires placed at right angles. Soon several companies in the eastern United States were producing electrically welded fencing for the expanding farm market. Thus, farm fencing represented the shipment of a product which later would reinforce concrete and be called welded wire fabric.

There was no simple, straight line progression from Perry's invention to the broad scale use of welded wire fabric or mesh, as it was (and is) commonly called. As expected of the highly individualistic early engineers, builders and men of steel, there were their several different design approaches to the reinforcement of concrete particularly in floor slabs and pavements. Four materials which would be tested in the marketplace and on the job were: expanded metal; a triangular woven wire

Test of Slab Reinforced with Clinton Electrically Welded Wire about 1915: In background, 4" slab, 1:2:4 concrete reinforced with Clinton Electrically Welded Wire, 3" x 12" mesh, No. 3 and No. 8 wires, giving area steel in longitudinal wires .187 sq. ins. per foot of width. Slab has center span of 12' with 3' cantilever at each end. In this view slab is loaded with 550 lbs. per square foot, but was subsequently loaded with 826 lbs. per square foot without failure. In foreground, slab of same dimensions, but reinforced with '18" sq. rods, 6'l4" on centers, giving steel area .249 sq. ins. per foot of width. This slab failed with load of 486 lbs. per square foot.

mesh; rectangular welded wire fabric; and staple tie rectangular mesh.

As early as 1906, Sweet's Catalogue, under the general heading of "Cement Fireproofing," displayed and described Clinton welded fabrics suitable for roofs, cinder concrete arches, stone concrete "wide" spans up to 15 ft., columns, walls and partitions.

In 1908 American Steel & Wire Company published a hardbound *Engineers' Handbook and Catalog of Concrete Reinforcement* which described the many applications of wire reinforcement for its time. Fireproof ceiling/floor systems, columns, concrete sewer pipe, and bridge decks were among the uses covered in this book.

Early pavement reinforcement was also accomplished with triangle mesh. One of the first pavement jobs was the Long Island Parkway completed in 1908. Here a lightweight mesh, weighing only about 0.2 lb./sq. ft., was embedded in crushed graded stone, rolled and grouted and rolled again. This and other early applications were not reinforced as we know it today. Nearly 50 years later, retired American Steel & Wire Company executive Perry Coons explained in a letter, "It was put in as a binder to hold the slab together after it cracked and it always did. The analogy to the wire mesh in glass was the best argument in its favor. We called them 'wire-bound' pavements, as well as `reinforced.' "

From these early years through World War I several eastern states specified wire reinforcement in their concrete pavements, with the weight of the mesh gradually increasing to about 0.65 Ib./sq.ft. The mesh was furnished in either sheets or rolls. When the specifier used rolls, he would be loaned a set of straightening cylinders which were set up on the job. The leading end of the mesh roll was pulled through the cylinders, hopefully straightened, and then cut into more or less flattened sheets.

Claim to the first known use of welded fabric in reinforced portland cement concrete pavement appears to have been shared by stretches of pavement built about 1910-1915 in DeKalb, Illinois; California and Forest Park, Maryland. However, the DuPont Road in Delaware must share some of the honors for the same general time period. First planned about 1911 and the forerunner in concept of all superhighways, it was laid out with dual lanes and a median strip for trolleys. The DuPont was reinforced with one of several materials-triangle mesh, circumferential bars around the slab perimeter, Kahn expanded metal and rectangular welded wire. Charles Upham, then a young engineering student who later became a respected designer and consultant in the highway field, importuned Clinton to furnish Delaware with three carloads of its "wire cloth" because he was convinced of the extra strength that fabric would impart to a concrete roadway. From 1915 to 1917, as the original portion of the DuPont was built south of Georgetown, many 400-ft. long slabs of the roadway were reinforced with welded wire fabric. Based on present day knowledge these panels were entirely too long but they performed reasonably well.

Although the DuPont Road was one of the early users of steel reinforcing, it was tried in other states as well. With the dawning of the automobile age and the need to "get America out of the mud," highway designers tried almost every combination of materials in a persistent search for better pavement. But from the pre-war days until the '20s, as far as distributed reinforcement was concerned, it was mostly a tug of war between the proponents of triangular mesh and those of rectangular mesh.

"Distributed" is the key word here-as opposed to the use of reinforcing bars at the slab edges. The arguments for both triangular woven or rectangular mesh, as taken from the sales literature of the time, were virtually interchangeable: "... provides a more even distribution of the steel, reinforcing in every direction"; "continuous, unbroken sheets"; "distributed loads"; ". .. continuous action from one end of the structure to the other"; "a most perfect mechanical bond"; ". . . a perfect adhesion of concrete to this fabric"; and even then, an early defense of rust which was later supported by research-". ., slight coating of rust provides a rougher surface and therefore a better bond!"

The reference to rusting brings out another yet unsettled aspect of the struggle to shape the wire reinforcement industry. Opinion was divided between a galvanized product vs. plain, with some of the companies now moving into the reinforcement field offering one or the other as an option. Eventually, of course, the plain product would win out.

An early reinforced pavement built in 1913 at the Oakland, California waterfront. Compare the man hours here with today's high-production pavement.

As more fencing companies became aware of a new potential use for their product as reinforcement for concrete, the trend toward rectangular mesh became more pronounced. In the early '20s; the Pittsburgh Perfect Fencing Company began national promotion of welded wire fabric. At the same time, American Steel & Wire Company began manufacture of rectangular welded wire fabric in addition to triangular mesh.

The design and research aspect became prominent as concrete researchers and engineers learned anew the lesson that bond was an integral requirement of reinforcement and that use of many, smaller wire members provided superior crack control to an equivalent amount of steel in a fewer number of larger diameter bars. An investigation into the properties of welded wire fencing would produce another strong, viable argument for the product as reinforcement.

Wire for welded wire fabric is produced by drawing hot--rolled rod through diamond dies. The drawing process changes the rod's physical characteristics and drastically increases its tensile strength. This higher yield strength compared to Grade 40 reinforcing bars with a yield of 40,000 psi gave wire fabric a competitive edge on a pound-for-pound basis.

With the woven triangular-rectangular welded confrontation mostly resolved in favor of wire fabric, the "battle" was far from over, according to M.E. (Ed) Capouch. Referring to the continuing campaign to gain acceptance for welded wire fabric, Capouch, a sales executive with American Steel and Wire Company (later a subsidiary of United States Steel) said:

"The battle was fought on the paving battleground. Prior to 1928, building fabric, except in New York City, was often considered a second class product despite the fact that it had been used extensively in some of the most prestigious buildings in America. Most fabric shipments were for pavement use. And that's where we fought for it."

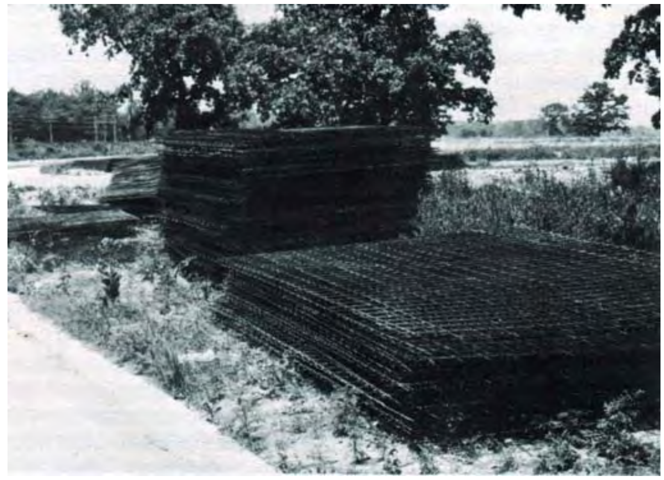
The "we" refers not only to his associates in American Steel and Wire, but to respected competitors in other fabric manufacturing companies such as Wickwire-Spencer Steel Company and National Steel Fabric Company (the successor to Pittsburgh Perfect Fencing Company, which later became the Pittsburgh Steel Company and is now Wheeling-Pittsburgh). Very early the men of these firms perceived a common cause and a shared interest in working together to gain acceptance for the reinforcement product still evolving from farm fencing!

More than a skirmish in the battle was the Bates Road Test. This was one of the first major "actual traffic" tests of roadway designs in the country. Built in 1922 near the small town of Bates, Illinois, it was to serve as a test of 78 different pavement designs as a prelude to developing a specification for the several thousand miles of highway to be built in Illinois with a sixty million dollar bond issue. The test was coordinated by the United States Bureau of Public Roads and the State of Illinois.

B.S. Pease and his associates were instrumental in persuading Illinois Chief Engineer Frank Sheets, who later became President of the Portland Cement Association, and Design Engineer Clifford Older to incorporate single five and six-inch thick uniform sections of concrete, each reinforced with 45 lb./100 sq. ft. of triangular mesh into the test. The 76 other 5- and 6-inch thick sections would include plain concrete of various mix designs and some of monolithic brick and asphalt-topped pavement. The straight-line test road was then subjected to constant speed and increasingly heavily loaded truck traffic. Performance in terms of cracking and breakage was recorded for each section after each thousand load applications.

The results offered convincing proof of the effectiveness of wire fabric as reinforcement for concrete pavement. In addition to the official record of the test, competent, non-fabric industry figures went on record about the results. Clifford Older, reporting at the 5th Annual Highway Research Board meeting stated:

"When a corner break appeared in a heavy-traffic road of this type, we knew from experience that, unless we made repairs at once, a considerable area of the adjacent pavement might soon be destroyed. We therefore expected the same results during the tests of the Bates Road, and our expectations were fulfilled as regards the plain concrete and monolithic brick sections ... In the wire mesh sections, subsequent progressive destruction was reduced to a comparatively insignificant amount."



Pavement fabric stored for Illinois job designed by Consoer, Older & Quinlan, June, 1931.

Another observer was Harold F. Clemmer, Materials Engineer for Illinois and a highly respected authority in highway and transportation affairs. Clemmer reported, "In this test, Section 51 (6-in. concrete with mesh reinforcing, 45 lbs. per 100 sq. ft.) is the only one of the 6-in. sections which was in sufficiently suitable condition after the final heavy test traffic that it could be left as part of the presently publicly traveled road."

The Bates Test was an important landmark for the proponents of distributed welded wire fabric reinforcement in concrete pavement. What they had known all along had been confirmed and would serve as added ammunition in the continuing battle for acceptance. American Steel and Wire, in its 1928 pavement handbook, attributed the increased recognition of fabric to the proof developed by the Bates Road Test with this statement:

Twenty years ago highway and city engineers who specified wire fabric reinforcement for concrete pavements had very little precedent to substantiate their judgment. They knew that concrete resists abrasion and wear ... They knew also that concrete had great compressive strength,-but little tensile strength. It was therefore apparent that steel reinforcement must be added as the pavement slab is subjected to stresses other than those caused by compression.

But, even with the Bates Test, there were other areas to be concerned about. With so much attention given to pavements, building applications had lagged except in New York City. But now, the early proponents of welded fabric, aware of the New York experience, were also aware that similar markets could exist elsewhere for building mesh.

The New York situation was nearly unique. Fire had plagued businesses and buildings since the city's first days, but even more so with the turn of the century. Pushing toward a solution, city building code authorities, working with the Underwriters' Laboratories, early in the 1900s conducted many fire and load tests on several building materials in various combinations. Both triangle mesh and rectangular welded fabric were tested as reinforcement in cinder concrete construction and both performed very well as reinforcement.

Specifically, the tests induced Elbert Oliver of the New York Bureau of Building to change the city's code to permit use of wire fabric in short span cinder concrete arch construction. This action placed fabric in a strong design position. This type of construction was later used in the Empire State Building. It is somewhat ironic that use of the so-called "cinder-arch" construction was approved by the fire code rather than the building code.

The fire test, the code changes, population growth and an early environmental problem now came together to create a booming new market for building fabric. In the city, coal-burning electric generating stations produced vast quantities of cinder and clinker to be disposed of. This material had already been established as an excellent aggregate for concrete. So, by 1915, as the city's first generation of skyscrapers sprung up in response to the demands created by more people and more business, the cinder arch concrete floor system reinforced with wire fabric was widely used.

Fabric was well suited to the cinder arch design. The material could be readily unrolled and "draped" into proper place in the thin cross-section of the slab-high above the beam and low at mid-point of the span. Many, actually most, of these early wire-reinforced floors are still in use. Often the building has been stripped to slab and frame and renovated. What worked so well in New York had to work elsewhere.

CHAPTER THREE

1926-1940: An Industry Grows-An Organization Is Formed

Fabric was widely used in Empire State Building-one of the world's most prestigious structures. All floor slabs used New York City's cinder arch construction method which required welded wire fabric.

By 1928 an industry existed. Reported shipments of welded wire fabric by the industry were nearly 152 thousand tons. The next year they approached 162 thousand tons, only a fractional percentage of reinforcing bar shipments, but not bad for a product that had started life about 25 years before as farm fencing.

The growth was hardly Topsy-like. Some might be attributed to chance, to a grasping of opportunity by companies aware of the rising interest in distributed reinforcement. But most growth came about as men of steel like Capouch and Robert L. (Bob) Glose (National Steel Fabric) and others became more and more aware of their common interest in '`selling" a concept and thus broadening a market. Their shared concerns would soon see them join in establishing a firm base for the use of building fabric.

Another early man of steel was Bill Kramer of American Steel & Wire. Taking the results of the Bates Road Test, he spent most of his time promoting the concept of distributed reinforcement to state highway departments. As a result of his work and others, the industry gained two more producers. Laclede Steel and Sheffield Steel (now a division of Armco, Inc.) entered the industry to help supply a new, growing market.

Something similar happened in Chicago. The "Wire Company," as AS&W was somewhat familiarly known in the late twenties, started promotion of building fabric and began to emulate the product's success in New York City. Not yet having local code recognition, each project for which fabric was proposed was approved on a case-by-case basis. Most of the applications were for rib-floor construction with the fabric being draped into place over pans which formed the slab portion of the short• spans. Early successful uses included the Tribune Tower, Palmer House, the old Stevens Hotel and Merchandise Mart, all of which became showcases for the fabric concept.

The industry leaders in the Midwest who promoted the use of building fabric in the Chicago and Milwaukee area relied for support on three resources: the New York experience; ASTM A-82 which was first published as a tentative specification for cold drawn steel wire in 1921, and which effectively defined the minimum strength of wire fabric; and the Bates Road Test. A report on the Bates Road Test was written by C.A. Hogentogler after a nationwide survey of the "Economic Value of Reinforcement in Concrete Roads," and was presented at the Fifth Annual Meeting of the Highway Research Board. It established that the closely spaced smaller wires in fabric were more effective in crack control as reinforcement than larger members spaced farther apart. Although the conclusion was based on a pavement study, the principles obviously applied to reinforcement in any slab taking into account the functional differences between crack control and resistance to tension in the structure.

Keeping informed and knowing the right people at the right time is certainly extremely helpful in getting ahead in any endeavor. The fledgling wire fabric industry was no exception. Men like Ed Capouch, B.S. (Bud) Pease (AS&W) and Bob Glose, all active in promoting the use of fabric in whatever application, had to know what was going on in their own market and in the overall field of reinforced concrete construction. They undoubtedly knew that the American Concrete Institute (ACI) planned to call its E-1 committee into session in 1928 at Philadelphia to initiate and promote a national building code for reinforced concrete construction. They also knew that F.R. McMillan Portland Cement Association had named representatives of his own organization along with men from Concrete Reinforcing Steel Institute (CRSI) and the Rail Steel Bar Association (RSBA) to comprise the E-1 committee. But they also knew from counterparts in PCA, CRSI and RSBA, that a "threat" possibly existed to "legislate" expanded metal and welded fabric out of existence in the national concrete building code.

Here's where a sound knowledge of the industry helped. Capouch had worked with McMillan during an earlier stint with PCA and had persuaded him that the wire fabric industry, although not formally organized, merited representation on the committee. So, to the Philadelphia ACI meeting went Capouch, Pease and Glose determined to obtain recognition of welded wire fabric in the code.

They succeeded. Wire fabric was included in the new ACI 318 code as an acceptable building material and "fabric" was defined so that it could be treated as equivalent to deformed bar, providing that wire spacings did not exceed 12 in. Quite obviously, all of the work done in those earlier, preparatory years helped assure the outcome: the fire tests, the New York experience, the Bates Road Test, the Hogentogler Report, the showcase buildings in Chicago and New York, and the persuasive powers of these dedicated men of steel. Without them the light building fabric and structural markets might have faded away as has expanded metal in the construction industry.

But need for a voice for fabric soon became apparent to these determined men. The need probably had been felt for several years. Reflecting on the competition, the other influences in the marketplace with their own organizations-such as PCA, CRSI, RSBA-and respectful of their demonstrated clout, Capouch, Glose, Pease and other leaders of the now recognized fabric industry acknowledged the imperative need for their own organization.

On May 14, 1930, they organized the Wire Fabric Institute with headquarters in the National Press Building in Washington, D.C. Founding members were American Steel & Wire Company, Keystone Steel & Wire Company, National Steel Fabric Company, Truscon Steel Company and Wickwire-Spencer Steel Company. First Engineer-Director of the Institute was Royall D. Bradbury, formerly instructor in structural design at the Massachusetts Institute of Technology and Vice-President in charge of the welded fabric department of the Clinton Wire Cloth Company. He had also worked as a private consulting engineer.

Wishing to broaden the scope of the new organization, the founders, only a month later, changed the name to the Wire Reinforcement Institute. In their announcement to the trade, the founders stated as WRI's purpose:

... to provide a centralized organization to exploit the technical and utilitarian merits of wire as used for concrete reinforcement. Wholly independent of the commercial interests of any single manufacturer, the Institute will function as a purely promotional organization, its activities including the assembly and dissemination of authentic information data and statistics relevant to Welded Wire Fabric and its uses.

Engineer-Director Bradbury immediately became active in representing WRI on various committees in the field. He replaced Capouch on ACI's E-1 Committee, sat in with several building code authorities around the country, and took an active part in ASTM Committee A-1 on steel. In 1936, ASTM published its tentative Specification for Welded Steel Wire for Concrete Reinforcement, A-185-36T, the first national specification on fabric.

Midwest paving job. Placing WWF for Indiana highway, August, 1931.

Bradbury was on a first-name basis with many of the engineers who came to Washington in the 1930s to man the various bureaus which were set up by the government in response to both depression-engendered legislation such as the National Industrial Recovery Act (NIRA) and the New Deal's increasing involvement in the affairs of its citizenry. Many came from architectural and engineering firms closed down by the Great Depression. Royall Bradbury was highly regarded for his integrity and competence in the field of reinforced concrete. So, when he called on them, carrying the message of welded wire fabric, he was welcomed as an eminently qualified engineer and trusted associate. As part of a program to stimulate housing, federal specifications were established for all aspects of home construction. Bradbury, supported by experienced engineers from the Chicago area who had designed extensively with welded wire fabric, succeeded in having 6x6-10110 welded wire fabric specified as reinforcement for the slabs of basement less homes in all federally insured housing in the United States. The results of this and later work would have cumulative bearing on code and specification action for years to come.

The first formal WRI research appears to have been conducted in 1933 by Warren Raeder, who investigated the bond strength of cold drawn wires individually and welded into fabric, compared to "ordinary" reinforcing and "wiped-galvanized, cold drawn wire." In 1935 Professor

T.D. Mylrea of the University of Delaware investigated the effect of spot welding upon the strength of cold drawn wire. Based upon his findings, code authorities increased the allowable steel stress for welded wire fabric in one-way slabs from 20,000 to 30,000 psi in spans up to 12 ft. Along with his committee work and administration of WRI headquarters, Bradbury was researching and writing what was to become a classic in pavement design circles. His manual entitled *Reinforced Concrete Pavements* was first published in 1938. This textbook, with its persuasive arguments for the need for distributed reinforcements in pavements, became an invaluable tool in the continuing campaign being waged for the acceptance of fabric. Bradbury led much of this campaign to many key highway people around the country. Many eastern states, in response to BPR's call for a so-called "ultimate" pavement design which would resist the destructive "pumping" on pavements due to heavy trucks, incorporated control-of-cracking-through-wire-fabric because of Bradbury's persuasion. BPR also required subgrade treatment to control pumping, as did several southern and midwestern states including Indiana, Wisconsin and Arkansas. Many of these states opted for welded fabric because of the subgrade drag theory which had been developed by Clifford Older, a staff member on the Bates Road Test. His theory enabled designers to space the joints farther apart and develop a rationale for specifying a definite area of steel per foot of width with which to control and hold structurally harmless any cracks formed between joints.

The "irony" lies in the fact that Older, in his role as Illinois Design Engineer, and Chief Engineer Sheets had selected in the late twenties as their standard a thickened edge (9-6-9 in.) concrete slab with 7/8-in. rebars along the edges of the slab. The pavement used no joints. This pavement performed about the same as the mesh reinforced pavements in the Bates Test. Discouragingly, these 9-6-9 in. pavements started to "blow" and disintegrate when placed in actual service. Governor Small, who was running for reelection, promised to build 1000 miles of concrete road and to get Illinois out of the mud. He also placed a ceiling price of $30,000 per mile-a constraint which could impair sound design decisions. Distributed reinforcement still was not approved despite the poor performance of the 9-6-9 inch jointless edge-reinforced pavement. Instead, engineers were instructed to develop a controlled, sealed expansion joint which would prevent pumping. Using 30-ft. centers, this design would result in plain concrete slabs short enough to be free of cracks. Illinois built over 1000 miles of pavement with this design. This design performed poorly. It was proposed that the University of Illinois, as a disinterested party, conduct a pavement survey and report its findings. In 1932, Governor Horner named Ernest Lieberman to be Chief Engineer of the Illinois Highway Department. Lieberman, a principal in the consulting engineering firm of Lieberman and Heim, had used welded wire fabric extensively in the Chicago area and been pleased with the performance of fabric reinforced pavements. Shortly, Illinois agreed to BPR's request that the 30-ft. long plain concrete slab with controlled expansion joints be dropped. The University of Illinois survey was scrubbed and welded wire fabric distributed reinforcement was specified for Illinois pavement.

As markets were saved, gained and expanded, the Institute as an organization was changing, too. In 1932, National Steel became Pittsburgh Steel Company, and in 1933, two new members, Wheeling Corrugating Company and Laclede Steel Company, joined. But 1933 was traumatic too. The nation was in the midst of the Great Depression and WRI coffers were poorer by $998.73 as a failed bank went under with fifty percent of Institute deposits. And, in that year the wire reinforcement industry in itself was organized under the National Industrial Recovery Act. Despite later Supreme Court invalidation of NRA and NIRA, that industry organization seems to have continued voluntarily for a few years.

The foregoing is conjecture since records for the period are either fragmentary or missing. An unfortunate loss of early institute files occurred when WRI's legal counsel, who had custodianship of certain files, inadvertently misplaced them when moving to new quarters. During the years from 1933 to 1937 a "Wire Reinforcement *Association"* existed with headquarters in Youngstown, Ohio. Its membership rolls virtually duplicated those of WRI and there seems to have been duplication of activity, too.

This duplication was to be resolved when the similar organizations were merged in 1937. WRI was the surviving entity. In 1939 the Youngstown office was closed and all operations were absorbed or continued in the Washington WRI headquarters.

By the end of the pre-World War II period, WRI membership stood at nine, as Sheffield Steel Corporation and Consolidated Expanded Metals Companies joined the founders and early members.

CHAPTER FOUR

1941-1945: WWF Goes To War

The war brought vast, wrenching changes for a nation and its people. Industry, particularly the construction materials industry, including, of course, welded wire fabric, was changed, too. Federal bureaus, authorities and administrations, many staffed or headed by dollar-a-year men from industry, issued comprehensive plans and regulations aimed at the most effective allocation of resources made suddenly scarce due to combat and support requirements. The use of reinforcing steel was rigidly controlled; for example, it was removed from new pavement construction entirely.

Total shipments of wire fabric by WRI members remained reasonably high during the war years, indicating that, although subject to government direction, its use as a reinforcement product was not being overlooked.

Some presumably unnoted (unless in a military history) "genius," observing tanks, weapons carriers and personnel carriers bogging down in the sands between landing craft and solid ground higher up on the beach, in a flash of typical American inspiration perceived another use for wire fabric. Large sheets of reinforcement, placed ahead of vehicles, improved traction, even under water! So *traction* mats were born.

Laid out on the air strips being hacked out of South Pacific atolls, or behind the lines as we advanced on Festung Europa, sheets of fabric also became *landing* mats. They helped fighters and bombers take off and land on shifting sand or rain-soaked, boggy soil. Thousands of tons of fabric went overseas for this crucial role.

Assessments on shipments of fabric had been slashed to a token payment of *a penny* a ton early in the war. This was in recognition of the fact that the treasury had a healthy surplus and expenditures on promotion during the war would have been inappropriate. Late in 1944, as the war approached its anticipated successful resolution, wartime restrictions were relaxed. WRI promotion and broader activity were resumed and assessments were restored to their previous levels.

CHAPTER FIVE

1946-1950: The Post-War WRI-What Was Good For One, Was Good For All.

"We decided that whatever was good for one, in the production of welded wire fabric, was good for all. We decided that no one company should have any advantage over another company-but that the more fabric that could be produced, and the more the demand could be increased, the better off everyone would be." Ed Capouch thus described the consensus reached by the members of WRI as they surveyed their market and their organization after the war.

WRI underwent two leadership changes during the post-war period. In 1945, Royall Bradbury resigned and was replaced by Theodore J. (Ted) Kauer. Kauer came to WRI from ACPA where he had been that organization's Assistant Secretary. His knowledge of the pipe industry, a key fabric market, made his appointment logical.

In 1949. Kauer resigned to accept an irresistible opportunity-that as Director, Ohio Department of Highways. He 'would be missed. Appointment of an effective replacement was imperative to maintain momentum. Frank B. Brown was lured to WRI from McKee Engineering Company in Cleveland where he had been the engineer charged with structural design. Brown knew concrete-and reinforcement.

Organizationally WRI changed, too. In 1945, Colorado Fuel & Iron Company joined the Institute. Consolidated Expanded Metals was absorbed into another organization and dropped out. But by 1951, membership had increased to 11 firms as Northwestern Steel and Wire Company and Forbes Steel Company joined. In May, 1946, WRI became WRI, Inc., as it incorporated under the laws of the state of Delaware.

As the post-war period closed, shipments by WRI member companies rose in response to a general economic upturn and to the Institute's increasingly effective promotional efforts. Most visible were publication in four successive years of four manuals directed to developing and broadening markets-General *Information, Airport Pavement Construction, Home Construction and Farm* Uses. In 1948, WRI manned its first trade show exhibit at the big Road Show in Chicago. Also, in 1948, working jointly with its pipe fabric-making members, the Institute, in cooperation with the United States Bureau of Standards and the American Concrete Pipe Association, formulated and published *Simplified Practice Recommendations for Welded Wire Fabric Reinforcement for Concrete Pipe.* This program reduced the so-called "standard" styles from 311 to 63 and resulted in economies of production, design and use.

WRI formed a technical committee in 1946. Under the chairmanship of activists including A.C. (Carl) Weber of Laclede in 1946-1950, and Capouch from 1951 to 1952, the Committee mandated and coordinated far-ranging, in-depth investigations into how welded wire fabric performed particularly at welded intersections and in reinforced concrete when subjected to load. Both bond strength and weld strength were to be quantified and guidance for both wire sizes and spacings, in relation to crack control, were expected to be attained. In essence, the Committee was seeking hard data to formalize what engineers familiar with the product knew intuitively. Review of cover pages of reports and theses from that period describe the scope of the work. E.A. Weinel of the Missouri School of Mines (MSM) investigated the bond value of plain wire. In 1948 he reported on *Mechanical Anchorage of Transverse Wires in Welded Wire Reinforcement Fabric.* In 1949, came two more reports from MSM-Alan A. Becker reported *Interrelationship of Transverse Anchorage and Bond in Welded Wire Fabric* and Frederick R. Heartz reported *Efficiency of Various Types of Reinforcement in Controlling Openings in Cracks in Concrete Pavements.*

That same year, 1949, the committee authorized the development of a weld tester, so that the industry would be able to "guarantee" the weld strength of its product. Again, this work involved testing of fabric samples. It was initiated at the Missouri School of Mines under the direction of Professor E.W. Carlton. In the course of their studies, the professor and a student developed a jig called the Carlton-Kilpatrick Weld Tester. This was the first generation of such devices. Because it held the transverse wire of the tested weld with a screw clamp it did not confine the weld as it would be confined in concrete. Consequently, the weld tended to be "peeled apart" and gave lower weld strength results when compared to the strength of a weld embedded and tested in concrete. While a step in the desired direction, the device required further improvements before being adopted industry-wide. Search for an improved device was made during the next few years, but was not finally realized until the mid-fifties.

In 1949, Dr. Arthur R. Anderson was retained to make strain measurements using electric strain gauges on wire fabric embedded in concrete and to measure the relationship between weld strengths as determined by the Carlton-Kilpatrick tester and those observed when fabric was tested in concrete. Dr. Anderson's study demonstrated a higher weld strength for fabric embedded in concrete over those obtained by the Carlton-Kilpatrick tester.

Thus an early order of business was to improve and refine the weld tester which would backstop the industry's claim to "guaranteed" weld strength. W.E. (Ed) Bradbury, a Research Engineer with Armco, whose work involved the design of improved products for the construction industry, accepted the assignment. He devised a method of holding both wires at the weld so that they responded to stress as if the weld were encased in concrete. This prevented the turning of wire or peeling of welds which occurred with the earlier device and produced more realistic strengths. After further testing and research, the device was presented to the American Iron & Steel Institute (AISI) Committee on Welded Wire Fabric Reinforcement Research where it was designated the "Wire Reinforcement Institute Weld Tester." It was subsequently adopted and incorporated into ASTM A-185 where it is still used to test welds in welded wire fabric. Neither inventor Bradbury nor Armco was inclined to patent the device. Instead, true to the "all for one, one for all" credo of the Institute, they felt it "would better serve the industry without any patent restrictions as to its use or manufacture."

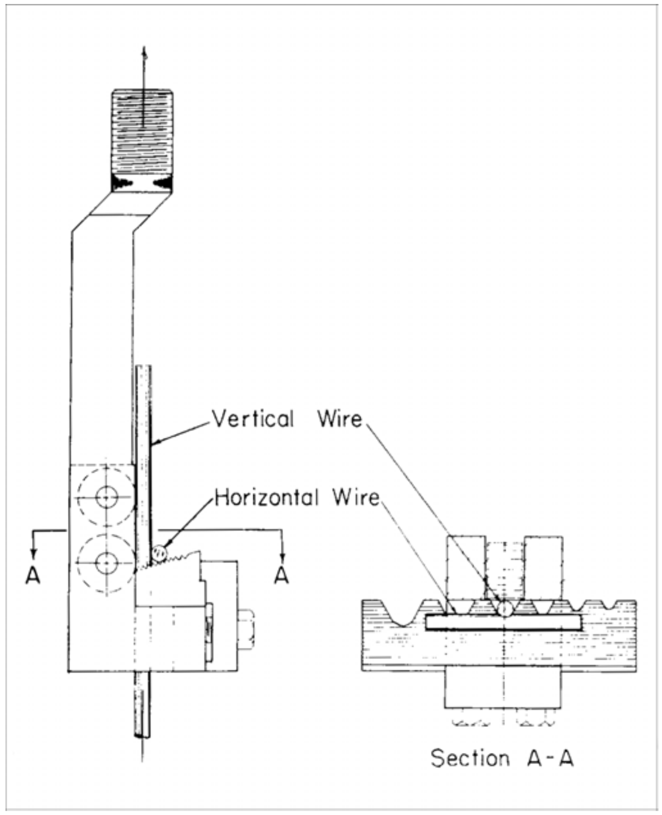


Figure 1. Weld Tester developed by W.E. Bradbury, It is still used to test welds for ASTM Specs.

Fabric was widely used at Pan American World Airways Terminal at New York City-a beautiful structure to say the least

Fifty Outstanding Projects in which welded wire fabric was extensively used (United States and Canada).

1900-1940

Long Island Parkway (1908),
New York

DuPont Road (1911),
Delaware

Biltmore Hotel,
New York City

Palace Hotel,
San Francisco

Grand Central Terminal,
New York City

Charles River Railway Bridge,
Boston

Phelan Building,
San Francisco

Chelsea Docks,
New York City

Brooklyn (N.Y.) Rapid Transit
(on 16 stations)

Empire State Building,
New York City

Merchandise Mart,
Chicago, Illinois

Chicago Tribune Towers,
Chicago, Illinois

Conrad Hilton Hotel
(formerly Stevens House), Chicago, Illinois

Palmer House Hotel,
Chicago, Illinois

1940-1980

Pennsylvania Turnpike

Ohio Turnpike

Indiana Turnpike

Illinois Turnpike

New York Thruway

Kansas Turnpike

Oklahoma Turnpike

Los Angeles Airport runways

Anaheim Stadium
(70,500 seats), Los Angeles

Major runways, O'Hare Airport,
Chicago, Illinois

Habitat '67,
Montreal, Quebec

Standard Oil Building
(80 stories), Chicago, Illinois

Hyperbolic Paraboloid Roofed library,
Hunter College, New York

Hyperbolic Paraboloid roofs,
Eli Lilly Plant, Indianapolis

Nabisco Bakery,
Chicago, Illinois

Hyperbolic Paraboloid Department store,
Denver, Colorado

Dormitories, Ohio State, Arkansas State, Laval, Wooster and many other Universities

United States Steel Corporation Main Office Tower,
Pittsburgh, Pennsylvania

Reinforcement for over 69,000 two-lane miles of pavement, 1950-1975

Reinforcement for over 75 percent of all concrete pipe

Parking garage, O'Hare Airport,
Chicago, Illinois

World Trade Center Towers,
New York City

First Bank Tower
(72 stories), Toronto, Ontario

Houston Intercontinental Airport

Pavement Dodger Stadium,
(56,000 seats) Los Angeles

Field House, Dartmouth College

J.C. Penney Mail Order Facilities
(slabs-on-ground)

G.E. Appliance Park,
Baltimore, Maryland

Hancock Tower,
Chicago, Illinois

IDS Complex,
Minneapolis, Minnesota

Sears Tower,
Chicago, Illinois

Volkswagen Plant,
New Stanton, Pennsylvania

Pan American Terminal Building,
New York International Airport

Mile High Center,
Denver, Colorado

Marina City Towers,
Chicago, Illinois

With some pride we suggest that the above list looks somewhat like a "who's who in buildings and construction.

CHAPTER SIX

1950-1970: "Is It Reinforced?" And The Interstate System

The Pennsylvania Turnpike is the granddaddy of the U.S. turnpikes and probably the Interstate System too. Its mesh-dowel pavement runs all the way from the Ohio line to Philadelphia and up to Scranton. We believe that this pavement was about 15 to 18 years old when this photo was taken.

The post-war WRI became new again, in orientation. With the producers able to "guarantee" the weld strength of their product, marketing and promotion of welded wire fabric and its Institute assumed a high priority.

In 1951, Joseph H. Senne, Jr., an associate of Carlton's, and Homer F. Thompson, a student, both of the Missouri School of Mines, published two reports on fabric - Investigation of Stress and Crack Distribution in Concrete Slabs Containing Welded Wire Reinforcement and Serrated Wire for Welded Wire Fabric. The second paper was WRI's first formal look in North America at what one day would be offered to the market as deformed welded wire fabric.

In 1952, William S. Housel, Engineering Research Institute, University of Michigan, made an interim report on his continuing WRI-sponsored study of *Plain vs. Reinforced Concrete Pavement,* in which probably for the first time aerial photography was utilized to document cracking patterns of in-service highways. The report concluded that reinforced slabs were outperforming the plain slabs in terms of fewer cracks and cracks more tightly closed or controlled.

All of the research had stated practical goals and often immediate applications in the marketplace. For example, in 1952, based on the results of the weld test program then available, the ASTM A-185 minimum weld strength requirement was upped to 35,000 psi.

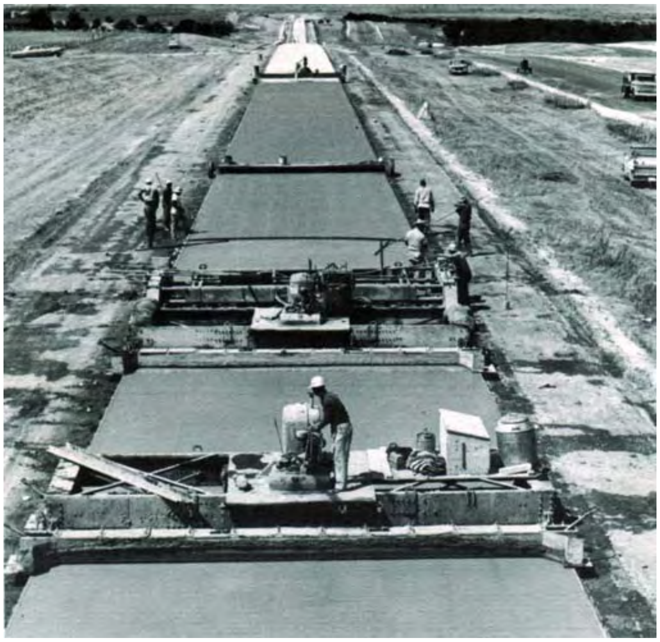
Another application of welded wire fabric had developed over the years and represented a major market. WRI records show a large tonnage of welded wire fabric being used in concrete pipe. This market had been carefully nurtured by the same men who had campaigned so vigorously for highway reinforcement. As in concrete pavement, the use of reinforcement in concrete pipe grew as the pipe market expanded, and as pipe was designed for greater loads and larger sizes. Today, a large percentage of all reinforced concrete pipe uses welded wire fabric as reinforcement.

Hiring of a staff public relations director, Don Gehring, the author of this history of WRI, marked the beginning of a conscious effort to make the public aware of the advantages of welded wire fabric in all construction markets. In 1956, a WRI committee staffed by industry advertising/ public relations people mounted a campaign to raise shipments in the residential market. Theme of the campaign: "Is It Reinforced?" Message: "If it's not, you're not getting your money's worth in concrete work around your home." Both the public relations and the advertising programs worked. A rise in shipments, not attributed strictly to normal growth or economic movement, could be noted. Member-company representatives reported increased awareness of wire fabric among clients, customers and professional associates.

During the period 1940 through 1960 a number of states built turnpikes. Virtually all of them used the traditional mesh-dowel design which incorporated distributed steel. The "grand-daddy" of turnpikes was the Pennsylvania Turnpike. Placed in service in 1940, the original section ran between Irwin, Pennsylvania (east of Pittsburgh) and Carlisle, Pennsylvania. Shortly after World War II it was extended from the Ohio state line to Irwin and from Carlisle to Philadelphia. All Pennsylvania Turnpike pavement utilized mesh-dowel design. Portions of this heavily traveled turnpike east of Harrisburg, built in 1949-1950, are still in service with the original concrete surface exposed.

Following the Pennsylvania Turnpike, these turnpikes were built using mesh-dowel design:

The Ohio Turnpike
The New York Thruway
The Indiana Turnpike
The Illinois Toll Way System
The Kansas Turnpike
The Oklahoma Turnpike



Interstate pavement under construction. This is mesh-dowel pavement going into place on the largest overall highway construction program ever conceived and built in the history of the world.

The largest factor in paving was, of course, the United States Interstate System. The merits of an integrated, logical national system of highways culminated in 1956 in legislation to create a "National System of Defense and Interstate Highways." The "Interstate System" evolved into the largest and most sophisticated highway construction program in the history of man.

Originally, the Act called for construction of 40,000 miles of dual lane highways linking almost every major population center. Later, mileage was increased to 42,500 and included Alaska and Hawaii. The highways were to be built, under the jurisdiction of each individual state, to nationally established design standards governing lane width, gradients and alignment, but the specifications for the pavement were to be set by each state in concurrence with and subject to federal approval. This presented an obvious challenge and opportunity to the proponents of the several different pavement design concepts then extant, utilizing both Portland cement concrete and asphaltic concrete. The wire fabric makers, individually and through WRI, met this challenge by carrying to state highways engineers evidence of the superiority of steel fabric-reinforced concrete in terms of both economy and long range performance.

To sharpen the focus of their campaign, the "right" man again came along. Henry Aaron was named WRI's Chief Engineer in 1955. His primary duties focused on the paving field. Aaron had a long, solid history of highway, airport and engineering experience. His most recent work had been with the Civil Aeronautics Authority (CAA) and BPR, where in the course of his duties, he had become knowledgeable of the needs of almost every state highway department in the lower forty-eight states. He was also acquainted with airport officials and consultants.

WRI estimates that between 1950-75 its members shipped enough paving fabric to pave over 69,000 two-lane miles of concrete pavement. Much of this fabric was used for Interstate pavements. Mesh-dowel pavements (or pavements with distributed reinforcement) were the most widely used concrete pavement type in the eastern, midwestern and southern portions of the United States. Mesh-dowel pavements were literally the "workhorse" of concrete pavements. Their overall performance has been excellent. They have carried many more vehicles and much heavier truck traffic than was ever anticipated when they were designed and constructed. As the Interstate System developed, knowledge of distributed steel (mesh-dowel) design and materials has further improved. Superior accessories such as epoxy coated dowels and joint materials with which to build even better reinforced concrete pavements are now readily available.

The following states made extensive use of mesh dowel reinforced concrete designed pavements in their Interstate Systems:

Alabama, Arkansas, Connecticut, Delaware,
District of Columbia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi. Missouri, Nebraska, New Jersey. New York, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Texas, Virginia, West Virginia and Wisconsin.

During this same period airport construction boomed and new runways were built in almost every major city. Mesh-dowel design was extensively used in many of these runways-and most of these runways are still in service. Some of the airports using mesh-dowel pavements were O'Hare Field, Chicago; Weir Cook, Indianapolis; Hartsfield, Atlanta; Detroit Metropolitan; Pittsburgh International; Cleveland Hopkins; Logan Field, Boston; Houston International; Love Field, Dallas; Billy Mitchell Field, Milwaukee; Los Angeles International; airports at Madison, Wisconsin; Green Bay, Wisconsin; Denver, Colorado; Columbus, Ohio; Dayton, Ohio; Fargo, North Dakota; Birmingham, Alabama, and many others.

Research Was Important

The welded wire fabric industry directly and indirectly funded extensive research work on welded wire fabric during this period. The American Iron and Steel Institute (AISI) Committee on Welded Wire Fabric sponsored studies at the University of Illinois and Massachusetts Institute of Technology. The University of Illinois work generally involved studies of welded wire fabric as a reinforcing material and of its performance in concrete. Professor Clyde E. Kesler, University of Illinois, directed much of this work with graduate students, many of whom are now outstanding engineers, professors and leaders in the construction, concrete, education and engineering fields. Professor Chester Siess also directed some of this research. Some of the graduate students who worked with Professors Kesler and Siess were Meta A. Sozen, Albert C. Bianchini, Amos Atlas, J.O. Jirsa, John P. Lloyd, Russell S. Jensen. John D. Mozer and Khalid Yasin.

Graduate engineering students strike off and compact freshly placed concrete for 1314" thick flat slab test structure at the University of Illinois College of Civil Engineering Laboratory. Slab is reinforced by especially manufactured welded wire fabric reduced to quarter scale in size and spacing (see foreground). Test structure, 15 feet square, is a quarter scale representation of a 60-foot square slab supported by four interior columns.

Other research during the period covered continued study of fabric in pavements and a new study of the use of fabric in lightweight aggregate concrete. Of course, not all of this research was under the direction of WRI. For example, an experimental, quarter-scale model of flat plate slab reinforced with welded wire fabric was tested at the University of Illinois under the sponsorship of several groups, among them interested government agencies. The Reinforced Concrete Research Council (RCRC) of which WRI is a member coordinated these efforts. Important research related to concrete pipe was accomplished under Frank Heger at M.I.T. With membership on this committee including many or most WRI members, the results of the work were available to all interested members.

The AISI committee also commissioned Professor Clyde E. Kesler, at the Engineering Experiment Station of the University of Illinois, to investigate the behavior and characteristics of deformed wire and deformed welded wire fabric as reinforcement of concrete. Dr. Heger's firm of Simpson, Gumpertz and Heger was retained to conduct similar studies of deformed fabric in concrete pipe. Both AISI and WRI were directly involved in this work. Wiss, Janney, Elstner and Associates were commissioned to study laps of deformed fabric in CRCP and stress/strain characteristics of both smooth and deformed fabric. Research on deformed fabric marked a major industry thrust at creating a new product and investigating new applications for it.

These research programs, with AISI, AS&W and WRI (and its member-companies) sharing the results, would result in standard specifications for both the wire and the fabric. In 1964, ASTM approved and published ASTM Specifications A 496 and ASTM A 497 on deformed wire and deformed welded wire fabric. This was later followed by acceptance of deformed fabric by AC! 318. WRI was the catalyst for the development of deformed wire and deformed fabric.

In 1958, a new 60,000 psi minimum yield rebar came to market for use in ultimate strength design procedures calling for high strength steels. To meet this proposition, a VVRI member-company survey was made to determine if the yield strength of fabric, after welding, could be raised from 56,000 to 60,000 psi. The response was affirmative so this change was presented to ASTM and accepted in ASTM A 82. In 1962, the yield strength was raised to 65,000 psi, making fabric's competitive position even more favorable.

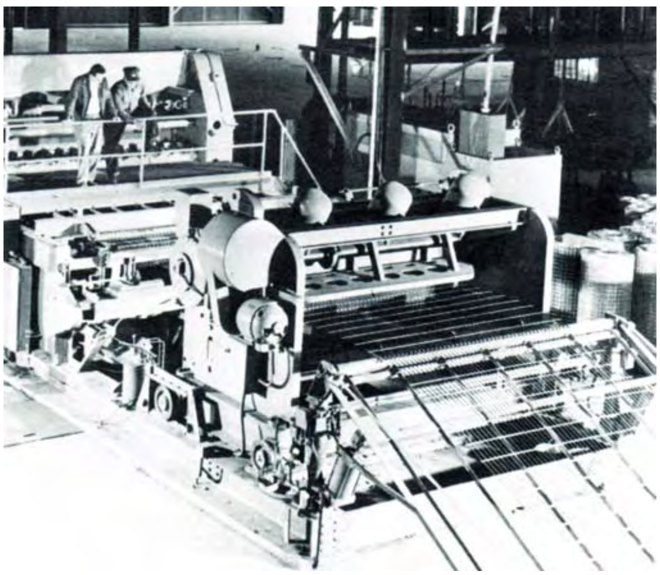
In the mid-'50s WRI looked at possible new uses and new markets. The reinforced asphalt program appeared to offer some potential. There is a perennial maintenance problem with roads and streets with the almost inevitable appearance of reflected cracks in asphalt concrete used to overlay older pavements. "Fabric-in-asphalt" was proposed to help cure this reflective cracking.

Edward (Ed) Howard, a former Asphalt Institute Engineer, joined the WRI staff in 1956. His mission was to consult with highway engineers in their trial applications of fabric-in-asphalt overlays and to develop data and literature which would assist them. Howard was instrumental in helping enterprising asphalt contractors develop "sleds" which ironed out the mesh and kept it from being entangled by the lay-down machine's distributor screw. A number of test installations were made in both the United States and Canada. Welded wire fabric appeared effective at bus stops and in other heavy traffic areas where frequent stopping and starting occurred. Welded wire fabric was found to reduce reflective cracking, but not enough to justify the additional cost of the fabric and the cost of installation.

Although this research and rather thorough investigation did not prove cost-effective, it was typical of WRI's questing spirit. William F. (Bill) Kuntemeier, a leader in those days, would recall: "The WRI group had enthusiasm for new projects and uses; we anticipated the need for business in future years-and we investigated many aspects and opportunities."

Another example of the industry's innovative approach to a better product, or to greater convenience for its customers, was hinged fabric. It was offered to the highway market by one or two fabric makers. The wide, heavy sheets of highway reinforcement, typically about $11\frac{1}{2}$ ft. (lane width) by 15 or 16 ft. long, could be folded down into a 6 ft. wide unit, by means of a "hinge" formed by wrapping the transverse wires around the longitudinal member about halfway across the sheet. The folded-down width of the hinged unit made over-the-road transport easier. To the best of our knowledge, no producer is currently making "hinged fabric."

Sometimes the customers beat the Institute or its members to new, unusual applications of fabric. In Cutler, Maine, the Navy, in its new long range radio station, used fabric not only as reinforcement for the cast-in-place wall structures, but with another unique purpose: the fabric sheets were welded to the steel framing to ground the entire structure to reduce interference by induced currents and thus facilitate effective transmission and reception.



New equipment opened the door to high speed efficient fabric production starting in the early 1950s.

WRI membership grew during the period, from 11 members to 17, including two members in Canada (the By-laws had been changed to accommodate them). New members were Continental Steel Corporation, the Steel Company of Canada. Ltd.. Tennessee Coal & Iron Division (USS), Planett Manufacturing Co., Ivy H. Smith Company, Davis Wire Corporation, Amco Mesh &_ Wire Company, Dosco Steel Ltd.. General Steel & Wire Co. and National Wire Products Co. Wickwire-Spencer was reorganized into CF&I Steel Corporation, Eastern Division, and AS&W and TCI were absorbed into their parent entity, the United States Steel Corporation.

The early welded wire fabric equipment was obtained by modifying equipment used to make welded and woven fencing. Later machines used at American Steel & Wire, Keystone and many other companies were designed and built by their company machine shops. These machines were well-built, sturdy and efficient for that period. As the industry became more sophisticated, a United States company began to produce National Welding Machines. They were actively promoted and sold to the industry during the fifties and early sixties. They were superb machines and many are still providing yeoman service and producing fabric economically and efficiently.

In the early sixties EVG, a firm headquartered in Austria, and BSG, a firm headquartered in West Germany, provided equipment with increased production capacity and the capability of producing heavier fabrics. The European equipment, which was developed for the European fabric market, produced fabric with sizes up to 5/8 inch in diameter, with speeds up to 100 cycles per minute. Schlatter of Switzerland and Robinson of California also offer fabric welding machines.

The steel and wire industry as a whole has made tremendous steps forward which have helped the welded wire fabric industry. Welded wire fabric is the largest single user of wire.

Improvements and knowledge of dies and the drawing compounds of soaps and equipment have vastly improved the efficiency of the industry over the past thirty or so years. Phenomenal wire drawing speeds are commonplace and have improved industry efficiency and economy. These advances were carefully researched and monitored by many persons, one of whom is Allan B. Dove. Mr. Dove is retired from Stelco, Inc., but is working harder than ever since retirement. Mr. Dove, who served as Chairman of WRI's Technical Committee for nine years, was made an Honorary Member of WRI in 1978 for his many contributions to the wire and fabric industries.

To prepare for increasing promotional and missionary work in the heavy structural fabric market. structural engineer Phil Weisz was added to the staff in 1961. In 1964, WRI moved its offices from the National Press Building, where it had been located since 1930, to Wisconsin Avenue. near the District-Maryland line.

Reflecting the Institute's re-orientation to marketing, the first of its motion pictures, "The Builders," was produced and distributed in 1954, and was shown extensively to interested groups in the United States and Canada for the next eight or nine years. It was a general interest movie and had a broad, non-technical appeal. It was followed in 1964 by "Structural Fabric-Time Saver for Builders." This film, built around actual case histories of successful, innovative uses of structural fabric, focused more sharply on the interests of engineers and contractors.

Several publications were developed in these years including the *Building Design Handbook,* which won top honors in a Producers' Council/Consulting Engineers' Council competition; a new *Airport Manual;* a revised *General Information Manual;* and a new publication, *Use of Deformed Fabric in CRC Pavements.*

Shipments increased dramatically during the period, peaking to an all-time high in 1958, and again to a new record, over 541.000 tons, in 1964. The increase in demand which these figures represent was generated by the combined effect of the several thrusts of the Institute's and its members' promotional efforts. This demand was met with a doubling in the industry's machine capacity with many machines able to weld wires up to 1/2 in. in diameter. The increasing use of heavy deformed fabric and structural fabric would require this greater capacity for many years.

A fundamental change was affecting the industry. In the '30s, when WRI was founded, all of its members were "integrated" mills. They had their own furnaces, produced ingot steel which was rolled into coiled wire rod. The wire for fabric was produced from wire rod.

Beginning in the fifties and early sixties, however, some businessmen, aware of the opportunities for growth and profit in the evolving wire fabric market, entered the industry as non-integrated producers. They purchased rod from integrated mills, many of which were fellow members in WRI, and converted the rod to wire and then into fabric. As the Institute celebrates its 50th Anniversary in 1980 the industry is divided about evenly between integrated and non-integrated producers.

The tonnage for structural fabric, a recently established category, was increasing. From a modest 2600 tons in 1961, it increased to the 22- to 26-thousand ton range in the late sixties and is now in the 50,000 ton category. This was attributed to the Institute's continuing promotion of heavy fabric in structural applications, including increasing attention to the role that deformed and bent fabric might play. Bending literally adds a third dimension to welded wire fabric. A West German company, Baustahlgewebe (BSG), developed efficient machines which can bend fabric sheets up to 40 ft. in length with great accuracy. These machines are widely used by precast and prestressed plants throughout the world. An American company, The Brush Machinery Company, now offers a similar machine.

Supporting the development of the bending concept was research in the late sixties, conducted for the Institute by ABAM Engineers of Tacoma, Washington. This work, which drew heavily on several studies by Baustahlgewebe, had as its purpose a study of the behavior of bent wire fabric as web and shear reinforcement. Some of ABAM's findings on shear reinforcement were incorporated into the ACI 318-71 Code.

Other code work also continued. In 1967, based on data from earlier WRI research, the Uniform Building Code (UBC) was revised to include all wire fabric provisions contained in ACI 318. An allowable design stress value of 30,000 psi for all fabric in all applications was used, as compared to 24,000 psi for Grade 60 rebars and 20,000 psi for Grade 40 rebars.

Finally, Federal Aviation Authority's (FAA) "Standard Specifications for Construction of Airports" was issued with WRI-sponsored recommendations "that rust will not be a cause for rejection provided the minimum dimensions and physical properties are not less than the requirements" for the steel specified. This clause was approved by ASTM and made a part of all wire and wire fabric specifications as a result of an intensive campaign by WRI staff and member companies, including WRI sponsored research conducted by Professor Kesler at the University of Illinois on the comparative bond and anchorage provided by rusted and bright, unrusted fabric. This must be recognized as an important achievement as it served to eliminate the problems of specification compliance that often troubled construction contractors and fabric suppliers.

In 1969, Frank Brown, who had guided the Institute's affairs for twenty years, retired and was "wished well" by the WRI Board and their guests at a dinner in his honor during the annual meeting at The Broadmoor. Chief Engineer Henry Aaron, well acquainted with Institute procedures, people and goals, was named Managing Director.

Deformed WWF being used on Dan Ryan Expressway. Chicago.

CHAPTER SEVEN

1971-1980: The '70s-WRI's Fifth Decade; Reorganization-Growing

As downbeat as were the preceding six years, the next 10 years must be rated "upbeat." Not that there wasn't some more adjusting and accommodating to do. If an industry has no problems there is really little need for an association. But, viewed against a backdrop of where WRI ended the decade, the obstacles fade to insignificance.

The backdrop is decorated with these data, on the record. From a low of 10 members in the late sixties, the membership rolls rose to 34 in 1980, representing 85 percent of all fabric produced in the United States and Canada. WRI further estimates that all of the WRI members in the United States, Canada, West Germany, New Zealand and Australia produce at least $1^1/_2$ million tons of fabric or about 30 percent of the fabric used in the free world. These 34 producers have been joined by a roster of 14 associate members who represent supporting industries.

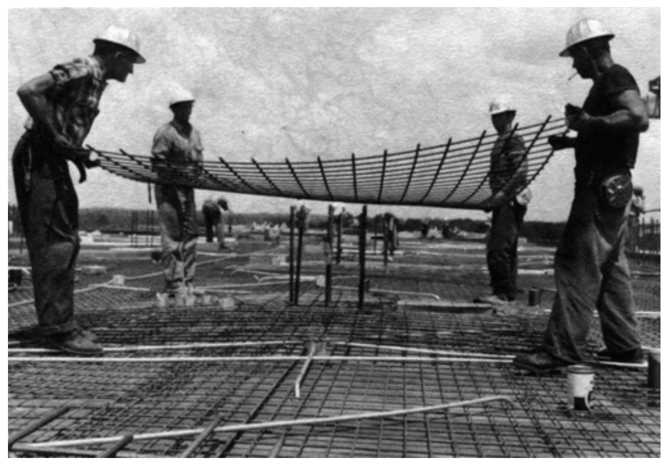
Also for the record, this interesting data: In 1930, 29,850,000 tons of portland cement were produced in the United States compared to shipments of 159,530 tons of wire fabric, a ratio of 187 to 1. Over WRI's five decades, that ratio has *dropped* to 135 to 1 in 1979, the last year for which complete records are available.

In actual tonnages, United States and Canadian shipments by WRI members during the period reached an all-time high in 1973-just under 725 thousand tons.

In 1972 the WRI office was moved from Washington to McLean, Virginia, close to the Beltway which encircles greater Washington, D.C. There were leadership and personnel changes during the period, too. Henry Aaron retired in 1971, to be succeeded by Walter L. Manifold, who brought his sales/marketing expertise from a member company, the Continental Steel Corporation (now Penn-Dixie Steel Corporation). He coordinated much of the broadened promotion of heavy building and deformed fabric which marked the first half of the seventies. William V. Wagner, Jr. was named as Technical Director in May, 1972. In 1973 David C. Jeanes joined WRI as Structural Engineer. One other change in the seventies involved Rita Deem who retired as Secretary and Office Manager in May, 1979, after almost 20 years' service. She worked under four Managing Directors and trained three of them-namely, Aaron, Manifold and Wagner. She was succeeded by Miss Sheila Sporl.

In 1974, Allan Dove, who had served as Chairman of the WRI Technical Committee, retired after nine years' service. He was replaced with another outstanding engineer-Robert D. Bay, Technical Director, Laclede Steel Co. Mr. Bay served until the committee was discharged in 1976 following WRI's reorganization.

Concerning reorganization, there were some obstacles on the way. These were a few more ups and downs in membership, and a low point was reached during the recession of 1974-75. At this point, spirits were low, too, and there was serious debate during this depressed market period as to how to continue the association. The "ayes" carried. And out of the travail came the impetus for reorganization, spurred largely by the then incoming WRI President, Fred West. A special By-laws subcommittee, chaired by Don Ballard, was formed to restructure the organization and make it more flexible in its ability +o meet changing circumstances and markets. Changes in membership definitions and classifications were approved. The organization was opened to support by fabric producers outside the United States and Canada, and by firms not directly in the manufacture of wire reinforcement, but allied to it, the Associate Members. Life Member and Professional Member classifications were also initiated.



As industry grew, more and more flat sheets were used for structural fabric. These four men are positioning about 200 sq. ft. of reinforcement in one quick operation.

The new by-laws also broadened the definition of the product almost in an echo of the action 50 years before in which the organization's name had been broadened from Wire *Fabric* Institute to Wire *Reinforcement* Institute and now specified only that members manufacture wire fabric or "wire reinforcement produced from cold-drawn and/or cold-worked steel wire, deformed or non-deformed." This then could include prestressing strand, metal concrete accessories, dowel baskets, masonry reinforcements and other products. Finally, the dues assessment system of financial support was changed.

To augment the reduced staff which necessarily would follow on the greatly reduced dues/income structure, provision was made in the by-laws for an establishment of several product development committees. These would respond to shifting conditions in each of several market areas and would be staffed by member company personnel. Thus, the long-standing WRI tradition of selfless, dedicated service for the industry ("What was good for one, was good for all") would be continued in contemporary form.

The upshot of all the foregoing was a WRI lean in staff and immediate budget, but revitalized as an organization; stripped and ready for rebuilding, and moving ahead again. The response was almost immediate. Former members who had dropped away rejoined, and new members signed up, including three overseas firms-Baustahlgewebe in West Germany, ARC in Australia, and Pearson, Knowles & Ryland Brothers in New Zealand. The Associate division quickly numbered 13 members, indicating that this support had been there all along and only needed to be asked! The Associate roster includes suppliers of wire rod and diamond dies for drawing wire and wire drawing lubricants, makers of machines for fabric production and bending equipment, producers of concrete accessories and others.

Concrete pipe in place. Inside diameter is 17 feet. Each section weighs 43 tons and required 4,000 lbs. of welded wire fabric.

WRI and ASTM were involved in an interesting problem in the very late sixties and early seventies. Up until this period, wire sizes had been designated by gauge numbers or by decimal inches. The industry and then ASTM changed to a letter-number combination. The letter "D" denoted a deformed wire and "W" designated a smooth wire. "W" was selected rather than "S" for smooth wire because of possible confusion between the letter "S" and numeral "5." The number that follows gives the cross-sectional area of the wire in 100ths of a square inch (or mm2 if you're metricized). The system is a direct aid to designers. The designation system is taking a long time to be accepted but all who use it seem to like it.

An ACPA-WRI Joint Committee developed a list of recommended standard styles for use in the concrete pipe industry in an attempt to reduce the number of general fabric style offerings for the concrete pipe industry. The committee provides a forum where each side can express opinions and then arrive at mutually agreeable recommendations.

The ACPA-WRI Joint Committee meets at least twice annually to discuss matters of mutual interest. Metrication for recommendation to ASTM Committee C-13 on concrete pipe has been one recent topic of interest.

WRI and PCI have also had two Ad Hoc Joint Committees. One discussed reinforcement for the top flanges of double-tees and the second made recommendations on single layer web reinforcement for "tees." Both reports were published by PCI.

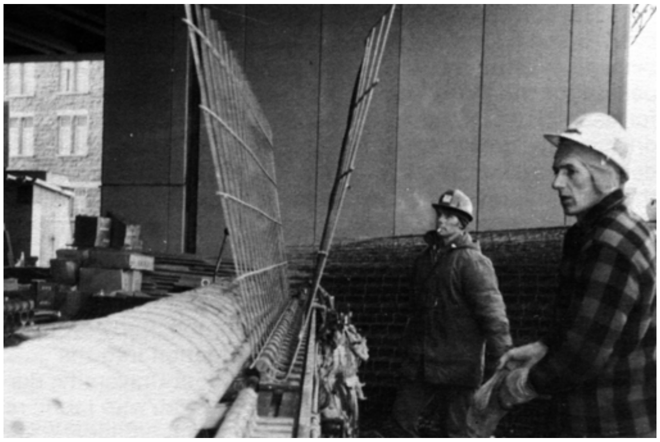
In June, 1976, Managing Director Walter Manifold resigned to accept a position as Vice-President, Sales, with the Atlantic Wire Company, a WRI member company.

William V. Wagner, Jr. was appointed Acting Managing Director. Wagner was appointed President and Managing Director at the Fall Board Meeting in November, 1976. Wagner is a registered Professional Engineer in several large states. He spent 22 years with PCA in several engineering and managerial positions prior to joining WRI.

Unlike some organizations in which associate members are dues-paying but only passive onlookers and money suppliers, the reorganized WRI provided that the associates,, through an Associate member division, would be active in Institute affairs, conducting their own activities in their spheres of interest and having one collective seat on the WRI Board of Directors. In similar manner, a Canadian Division was formed within the Institute. This entity is charged to respond to special Canadian problems and conditions, but in coordination with overall market objectives of the Institute.

The cumulative effectiveness of continuous promotion by WRI and by individual members of light building fabric became evident, too, during the period. From about 35 to 40 percent of total WRI shipments in the sixties, this product, for use mostly in residential construction, floor slabs, driveways, sidewalks, patios, had risen by the end of the decade to well over 50 percent of all shipments. Typical of this promotion was publication in 1977 of a 16-page pamphlet outlining uses and correct applications of fabric in residential and light construction.

Research projects during the period included a study into splice requirements in one-way slabs at Oklahoma State University; a University of Washington study on the fatigue properties of wire fabric; investigation into the action of fabric in two-way slabs at Rutgers University; development of design procedures for industrial, wire fabric reinforced slabs-on-ground by Austin Research Engineers; and design criteria for CRC pavement overlays by the same firm.



Bending equipment introduced by BSG became widely used in the 1970s and greatly expanded the use of fabric with the precast and prestressed industries and with contractors.

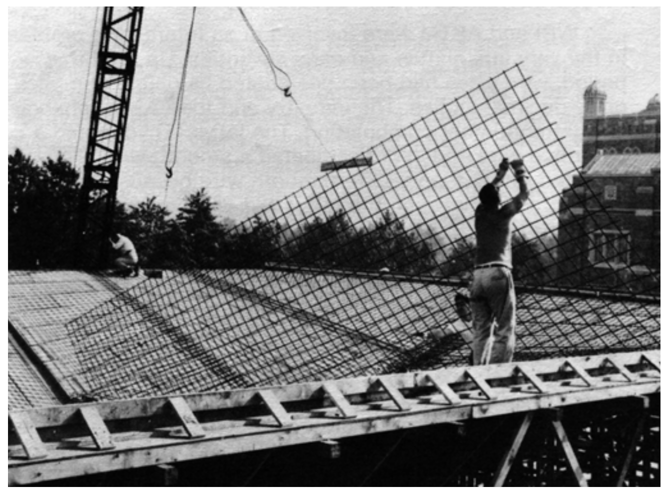
Subsequent to the Institute's reorganization, the newly formed Canadian division took on a tough assignment that of leading the Canadian manufacturers to ultimate metrication of their industry. After in-depth investigation and study, they published in 1979 their findings and recommendations for "soft" conversion including typical recommended standard styles for metric wire fabric. This work is just starting and the next step will be to move into hard metric conversion.

In 1971, the new ACI building code (ACI 318) was published. It incorporated several changes concerning wire fabric which were based upon research work sponsored by the Institute and AISI, particularly at the University of Illinois. WRI published its *Manual of Standard Practice,* which referenced ACI 318 building code requirements pertaining to fabric. It included splice requirements, bends and hooks, anchorage of web reinforcement, and provisions for use of deformed fabric. All of this contributed to further growth in the heavy building and structural markets. A second edition of WRI's *Manual of Standard Practice* based upon ACI 318-77 was published by WRI in 1979.

An industry and an organization had changed. From a membership in the thirties consisting solely of integrated mills, production is now even between integrated and nonintegrated producers.

Of the original seven members who founded WRI, three remain in the Institute; Keystone and Armco (Sheffield) as regular members and U.S. Steel as an associate member. Three of the other four companies no longer produce fabric.

But the Institute has weathered all these changes in membership, in markets, in economic conditions. Shipments are up, uses for, and of, fabric are increasing, and today's men of steel who guide WRI's affairs are dedicated to the same concepts which guided those men of 50 years ago-a superior reinforcing product in an ever better end product-reinforced concrete.



Lathers guide crane-hoisted 700-pound sheet of steel welded wire fabric into place on form work for one of the six hyperbolic-paraboloidal umbrellas of Hunter College library roof, New York City. Four-man lather crew placed 12 reinforcing sheets (over four tons) for each umbrella in half a day.

CHAPTER EIGHT

1980-2000: Now Where?

Lambot, Wilkinson, Perry ... Glose, Stewart, Capouch - Those names are on the record. The men who will lead WRI and the industry into the 21st Century are already at work-and they will be joined by others of a questing, innovative cast of mind. They'll probably lead toward ever higher strength wire fabric-72,500 psi (500 MPa) already is an achievable goal. They will expand the uses of fabric into tilt-up adaptations, tunnel forming, modular construction, etc. They will continue to explore and expand upon the many positive contributions of fabric to reinforced concrete construction. Reinforced concrete is the construction material of the future. Welded wire fabric and the Wire Reinforcement Institute will be working to promote reinforced concrete.

As did the earlier leaders, they will contribute to the betterment of an industry. They'll continue to work together -all for one, one for all.

CHAPTER NINE

1980-2000: WRI is Ever-Changing – For the Better

Changes were many in these two decades: the ACI318 Building Code adopted, in the 70's, a method of calculation known as the "strength design method". This gave the structural engineer the opportunity to create more economical designs then when using the older "working stress method", without compromising design integrity.

By 1980 most engineers were using "strength design" rather than "working stress", which became the alternate design method in the Code Appendix A. This also gave WRI members the opportunity to offer engineers grades of wire reinforcement to yield strengths of 80,000 psi (550 MPa). One of the first projects to require high strength wire reinforcement was Continental Plaza in Seattle, Washington. A WRI member and the engineer convinced the City of Seattle Building and Safety Department Grade 75 wire was feasible for confinement in the concrete columns of this 37 story ductile frame in Seismic Zone III. This was followed by the design of Pacific Park Plaza, Emeryville, California a 30 story special concrete moment frame in Seismic Zone IV. The engineer's design required a yield strength of 75,000 psi for confinement column ties at 2'/2" spacings. Beam stirrups were also specified as wire reinforcement because of rapid placement, which resulted in reduced labor costs. On October 17, 1989, a major seismic event, known as the Loma Prieta earthquake, with a magnitude of 7.1 shook the San Francisco Bay area. Although there was extensive damage to buildings and bridges on both sides of the bay, Pacific Park Playa, came through the event without damage.

In March of 1986, WRI was given the opportunity to join a research program to study seismic response to large deformations on full-scale beam column joints. WRI members would design two specimens, which were industry funded, and would be tested at the University of Texas, Austin. Industry provided high strength (fy=80,000 psi) welded wire for column ties and beam stirrups. Conclusions of the research were specimens with high strength wire performed as well as the other conventionally designed beam/column joints, while using less steel.

Other research programs, conducted independently in Canada, Japan and New Zealand, confirmed the University of Texas test results for equal or greater ductility and serviceability using high strength welded wire reinforcement.

High strength welded wire had come of age!

This next step was for industry to influence changes in the ACI318 Building Code to reflect the acceptance of high strength welded wire for resistance to shear. This took 12 years to accomplish, but in the 1995 Code cycle limit for shear was raised from 60,000 to 80,000 psi for deformed welded wire reinforcement. In the same time frame, epoxy-coated wire and welded wire were added to both ASTM Standards and the Building Codes.

In 1991 it was apparent materials standards should be amended to include high strength wire. A proposed draft was submitted to ASTM Subcommittee A01.05 for review and balloting. On the third ballot supplements to A82 (plain wire), and A496 (deformed wire) were added to reflect standards for high strength wire to a stress level of 80,000 psi, corresponding to a strain of 0.35%. In 1997, the wire sizes were increased for plain and deformed wire and welded wire to 3/4 inch diameter, or 0.45 sq. in. (290 mm) in cross-sectional area, to reflect the greater welding capacity available in the industry. In 1998 the first ASTM subcommittee ballot for stainless steel wire and welded wire reinforcement was a reality.

In the decade preceding 1990, WRI was again restructured to meet the current demands of the institute and industry. A strong marketing committee was formed to oversee the annual budget and to carry out programs which would be of greatest benefit to the institute and its members. This committee answers directly to the Executive Board and the Board of Directors. The Technical committee is an umbrella over the previous product development subcommittees, namely pavement, building, pipe and structural. In 1995 a Codes and Standards subcommittee was formed, all of which answer to the Technical Director, who in turn reports to the Executive Board.

It is the Technical Committee's responsibility to identify and monitor the numerous research programs being conducted on wire throughout North America and in other countries. Some of the more noteworthy research programs conducted during the period between 1980 and 2000, were:

Interior joint bi-directional seismic loadings using high strength WWR for beam stirrups and column ties - University of Texas, Austin.

Welded structural wire reinforcement for columns - University of Texas, Austin.

Ductility improvement of concrete structural members using high strength hoop reinforcement - Kyoto University, Japan.

Tests to determine performance of high strength deformed welded wire stirrups - McGill University, Montreal, Quebec.

Research on bonding properties of 3/4 inch deformed wire (D45) in concrete - Oklahoma State University, Stillwater, Oklahoma

Study of structural behavior of concrete slabs reinforced with WWR vs. slabs reinforced with fibers - Ohio Northern University, Ada, Ohio.

CHAPTER TEN

WRI Annual U.S. Shipments in Tons

Year	**Annual Tons** (The Best Year of the Decade)
1928	151,778
1929	161,995
1930's	159,529 (1930)
1940's	240,530 (1951)
1950's	458,602 (1958)
1960's	538,067 (1965)
1970's	724,814 (1973)
1980's	617,795 (1984)

Year	Annual Tons (No. of US Members Reporting)
1990	549,373
1991	457,164
1992	448,816 (7M)
1993	469,049 (7M)
1994	558,598 (8M)
1995	605,384 (8M)
1996	504,998 (6/7M)
1997	550,000 (5M)
1998	594,626 (5M)
1999	753,835 (7M) A Record!
2000	814,791 (7M) Another Record!!

CHAPTER ELEVEN

WRI – 70th Anniversary 1930-2000

Some significant projects where high strength welded wire was extensively used:

Continental Plaza Building
Seattle, WA

Pacific Park Plaza
Emeryville, CA

San Francisco State University Residence Hall
San Francisco, CA

Hyatt Regency Hotel
Sacramento, CA

Harbor Place Tower
Long Beach, CA

Crocker Plaza
Long Beach, CA

Golden Shores Plaza
Long Beach, CA

One Peachtree Office Tower
Atlanta, GA

Country Club Condominiums
Long Beach, CA

Flamingo Hotel Expansion
Las Vegas, NV

Rio Vegas Hotel
Las Vegas, NV

Sam's Town Casino Resort
Las Vegas, MV

San Antonio Airport Runways
San Antonio, TX

Columbia Center
Seattle, WA

Marriott at Rivercenter
Covington, KY

Jacob's Field
Cleveland, OH

Brown's Stadium
Cleveland, OH

Baltimore Ravens Stadium
Baltimore, MD

Camden Yards Ballpark
Baltimore, MD

Seattle Mariner's Park
Seattle, WA

Seattle Seahawks Stadium
Seattle, WA

Milwaukee Brewer's Ballpark
Milwaukee, WI

Texas Ranger's Ballpark
Arlington, TX

OFFICERS, MEMBERS OF THE BOARD OF DIRECTORS, ASSOCIATE MEMBER COMPANY REPRESENTATIVES, AND WRI STAFF (As of April 27, 1999)

Officers

Chairman of the Board	Alan White
Vice Chairman of the Board	Larry Virtue
Secretary/Treasurer	David Weinard
Immediate Past Chairman of the Board	Mike Quirk

Member – Board of Directors and Alternate Directors

Anchor Wire Ltd.	Lynton Russell
Cargill Steel & Wire	Larry H. Virtue
Chain Link Fence & Wire Products	Rafael J. Nido, Jr.
Connecticut Steel Corporation	Alan White
Davis Wire Corporation	Mike Quirk
Eastern Reinforcing Ltd.	James Kelly
Engineered Wire Products	John Thomas
Fertek, Inc.	Michel Tasse
Gerdau Productos	Luis Rodolfo Moraes Rego
Golik Metal Manufacturing Co., Ltd.	Robert Keith Daves
Hallett Wire Products Company	Wells McGiffert
Insteel Wire Products	Richard Wagner
Insular Wire Products	Tony Fernandez, Jr.
Iowa Steel & Wire	
Ivy Steel & Wire	Mike McCall
Oklahoma Steel & Wire Co.,Inc.	Max Moore
Tah Chung Steel Corporation	Frank T.M. Chen
Tree Island Industries, Ltd.	Ted A. Leja

Associate Member Division Representatives

3M	Jerry Gentile
3M Electrical Specialties Division	Jim Riemenschneider,
A.W.M. sri Automatic Welding	Claudio Bernardinis Machines
B.L. Downey Company, Inc.	Bernie Downey
Cascade Steel Rolling Mills	Glen Peterson
EVG, Inc.	Fred Bresani
Herberts O'Brian Powder	Fritz Hermann Products, Inc.
Impianti Industriali SPA	Roberto Mawglia
Lane Enterprises	Bob Garretson
Keystone Steel & Wire Company	John Meyer

WRI Technical Director

Wire Reinforcement Institute	Roy Reiterman, PE.

Legal Counsel

Howe, Anderson & Steyer, P.C.	Robert J. Weil

MEMBERS
WIRE REINFORCEMENT INSTITUTE
(AS OF JULY 1, 2006)

MEMBER COMPANIES

U.S. PRODUCER MEMBERS

Connecticut Steel, Wallingford, CT
Davis Wire Corp. , Kent, WA
EWP, Inc. , Upper Sandusky, OH
Gerdau Amersteel, Addison, TX
Insteel Wire Products, Mt. Airy, NC
Iowa Steel and Wire, Centerville, Iowa
Ivy Steel and Wire, Houston, TX
Oklahoma Steel & Wire Co, Inc., Madill, OK

CANADA PRODUCER MEMBERS

LEC Steel Inc., Brantford, ON
Numesh, Inc., Laval, Quebec
Tree Island Industries, Ltd. New Westminster, BC,

OVERSEAS PRODUCER MEMBERS

Prefabricados, Guatemala City, Guatemala

ASSOCIATE MEMBER COMPANIES

B.L. Downey Company, Inc., Broadview, IL
Dupont Powder Coatings U.S.A., Inc., Houston, TX
EVG, Inc., New York, NY
Ferrostaal Inc., Houston, TX
Ideal Welding Systems, LP, Rockford, IL
Lane Enterprises, Carlisle, PA 17013
Schlatter Inc., Rockford, IL
The Marvin Group, Inc., Burlington, KY
Morgan-Koch Corp., Worcester, MA 06105
3M Corrosion Protection Products Dept., Maplewood, MN

HONORARY MEMBERS

Simpson, Gumpertz & Heger,	Dr. Frank J. Heger
University of Texas/FSEL	Dr. James 0. Jirsa
Route 3, Fisher Road	Dr. Clyde E. Kessler
Eastern States Steel	Richard A. Swenson
University of Nebraska	Dr. Maher Tadros

PROFESSIONAL MEMBERS

Robert B. Anderson Engineers	Robert B. Anderson, P.E.
Baumann Engineering	Harms U. Baumann, P.E., S.E.
Pt Manunggal Multidaya	Hendra Gunawan
Mel C. Marshall Industrial	Mel C. Marshall
Robert C. Richardson & Assoc.	Robert C. Richardson

LIFE MEMBERS

Retired: Price Brothers, ESP	Emerson Heisler	Consultant
Retired: Cargill Steel & Wire	Jim Kairies	Consultant
Tara Engineering Services	Joe Kelleher	Retired: Expo Steel & Wire (Insteel)
Retired: 3M Company	Jim J. McDermott	
Retired: Ivy Steel & Wire	Richard Ramsey	Consultant
Retired: Ivy Steel & Wire	Robert C. Richardson	Consultant
Retired: Expo Steel & Wire (Insteel)	Richard V. Smith	
Retired: WRI Executive Director	Bill V. Wagner, Jr.,	Retired: WRI President

"MEN and WOMEN OF STEEL", An update to Year 2000 (An addendum to the Men of Steel -1930-1980)

ROLL OF HONOR

Chairman of the Board

1981	Howard Woltz, Jr.	Exposaic
1982	Robert C. Richardson	Davis Walker Corporation
1983-1984	R. A. Ramsey	Ivy Steel & Wire
1985-1986	Edward Lauther	Forbes
1987-1988	Richard Smith	Exposaic
1989-1990	Jerry Seling	National Steel & Wire
1991-1992	Jim Kairies	Cargill Steel & Wire
1993-1994	John Thomas	Engineered Wire Products
1995-1996	J. M. McCall	Ivy Steel & Wire
1997-1998	Mike Quirk	Davis Wire Corporation
1999-2000	Alan White	Connecticut Steel Corporation
2001-2002	Larry Virtue	Cargill Steel & Wire
2003-2004	David Weinand	Oklahoma Steel & Wire
2005-2006	Richard Wagner	Insteel Wire Products

Chairman, WRI Technical Committee

1946-1950	A. Carl Weber	Laclede
1951-1952	M. Edward Capouch	USS
1953-1954	Richard H. Frizzell	CF&I
1955	P.J. Callahan	Republic
1956-1957	A.B. Greene	Republic
1957-1958	W.F. Kuntemeier	Laclede
1959-1960	Wayne O. Stoughton	Pittsburgh
1961-1962	D.A. Stevenson	Republic
1963	G.W. Bowlby	Stelco
1964-1973	Allan B. Dove	Stelco
1973-1976	Robert D. Bay	Laclede

Managing Directors

1976-1986	William V. Wagner, Jr.
1987-1991	Milton Sees

Technical Directors

1991-1992	Loten T. Masker, Jr.
1992-2002	Roy H. Reiterman

Marketing Committee Chairmen

1989-1990	Jim Kairies	Cargill Steel & Wire
1991-1992	John Thomas	Engineered Wire Products
1993-1994	J. M. McCall	Ivy Steel & Wire
1995-1996	Mike Quirk	Davis Wire Products
1997-1998	Alan White	Connecticut Steel