Evaluation of Welded-Wire Fabric in Bituminous Concrete Resurfacing

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•AN EXPERIMENTAL project was undertaken in Illinois to determine the effectiveness of welded-wire fabric in the prevention or retardation of reflection cracking in bituminous concrete resurfacing on an old portland cement concrete pavement. "Reflection" cracks are those cracks that commonly appear in bituminous resurfacing immediately over cracks and joints in the portland cement concrete serving as a base.

Various methods have been employed by highway agencies to prevent or minimize reflection cracking, including the use of a granular cushion coarse, subsealing or mudjacking of the concrete slabs, extra-thick overlays, and welded-wire fabric. This study is concerned with one type of welded-wire fabric as the dependent variable in the experiment, as to its presence or absence and to its effective width, with all other factors considered to be essentially the same.

Illinois for many years has been engaged in an extensive program of rehabilitating many miles of existing portland cement concrete pavement by widening when necessary and resurfacing with bituminous concrete. Some form of rehabilitation had become necessary owing to poor riding quality and high maintenance costs. The rehabilitation program has not only made possible the restoration of the riding quality of these pavements but has extended substantially the service lives of existing highway facilities. Many more miles of existing pavement each year can be rehabilitated by widening and resurfacing than would have been possible if complete reconstruction were attempted.

Although the performance of nearly all resurfaced pavements has been satisfactory, it has been demonstrated that reflection cracking occurs after only relatively short periods of service life, particularly on routes carrying high volumes of heavy truck traffic. The reflection cracks occur not only over the cracks and joints that exist in the original pavements, but also over the longitudinal joint formed when widening strips are used to furnish a wider base for resurfacing. Reflection cracks in themselves do not appear to affect the riding quality of a pavement to any great extent, but experience has shown that these cracks progress to a stage of distress known as belt cracking (a pair or series of closely spaced parallel cracks) and ultimately to the spalling or dislodgement of material between these cracks. The advanced state of deterioration seriously affects the riding quality, reduces the potential service life of a resurfaced pavement, and intensifies the maintenance problem.

Engineering literature indicates that the installation of welded-wire fabric in a bituminous resurfacing over concrete probably was introduced in Texas in 1946. Numerous other installations of the kind have been placed since that time, using various sizes and configurations of wire-mesh reinforcing. In some instances, the reinforcing has been placed over the entire pavement surface, whereas in others, strips have been placed only over joints, cracks, and deteriorated areas. The location of the reinforcement in reference to a horizontal plane has been varied, sometimes being at the old pavement surface and sometimes being between the layers of the bituminous concrete resurfacing.

Encouraging reports from many of the earlier projects led to the establishment of the study involving the use of welded-wire fabric in an experimental construction project of bituminous concrete resurfacing in Illinois. After 5 yr under traffic, this installation is showing superior performance at locations where the fabric was used.

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DESCRIPTION AND LAYOUT OF PROJECT

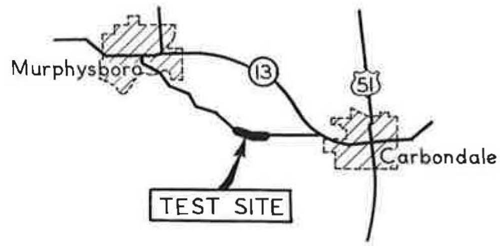

Figure 1. General site location.

This experimental installation was incorporated in the widening and resurfacing of Section 12RS-1, SBI Route 13, Jackson County, for the rehabilitation of an old portland cement concrete pavement. The project is located about 60 mi north of the southernmost tip of Illinois, between Murphysboro and Carbondale (Fig. 1). The annual precipitation at the site averages about 44 in., with little variation in the average monthly rainfall throughout the year. In the winter, the soil seldom remains frozen for any extended period, and there are relatively few freeze-thaw cycles. Normally, the average depth of frost penetration is less than 10 in.

The topography at the site is typical of the upland, rolling portions of Jackson County and the surrounding areas. The soils are light-colored and moderately slowly permeable, developed from thick to moderately thick loess. Silty loam soils of the A-6 group predominate.

The original improvement was constructed in 1925, with the then-current practice of light cut-and-fill sections. The pavement, placed directly on the silty loam soils, was constructed of plain concrete 18 ft wide and to a 9- by 6- by 9-in. cross-section. No transverse joints were used except for construction stops. Steel bars, $\frac{3}{4}$ in. in diameter, were installed at each pavement edge. A full-depth metal plate was used to form a center longitudinal joint, with the adjoining slabs being tied by deformed steel bars. The pavement underwent extensive portland cement concrete patching and maintenance repair in the 1940's. At the time of resurfacing, it had numerous wide transverse cracks accompanied with serious spalling and faulting. Intermittent areas of scaling had occurred throughout the entire length, and many of the old patches were severely raveled.

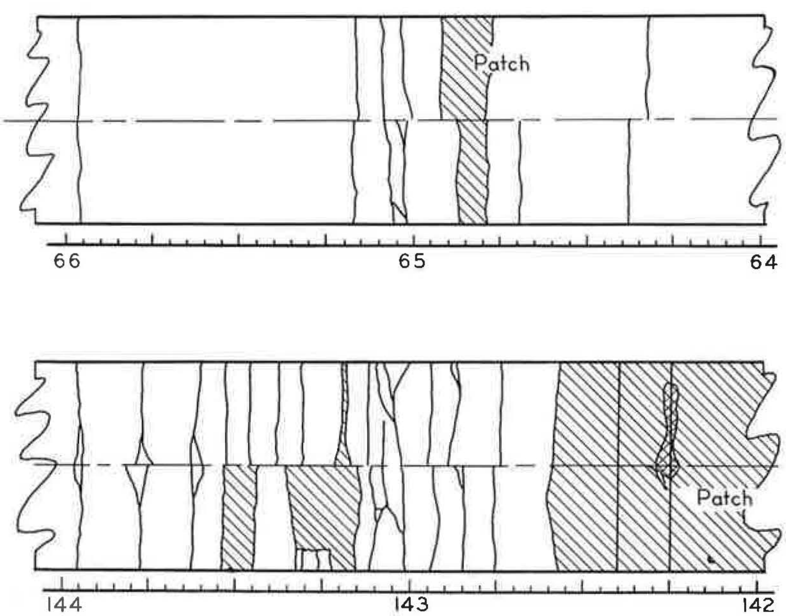

Figure 2. Typical condition of old concrete pavement.

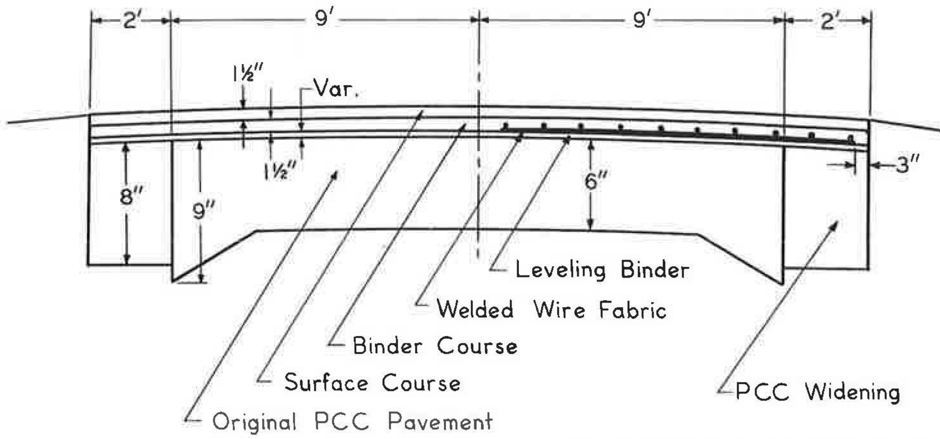

Figure 3. Typical cross-section.

A comprehensive condition survey of the existing pavement was made before resurfacing. A representative field survey sheet typical of the condition of the old concrete pavement is shown in Figure 2.

The 1958 rehabilitation consisted of widening the existing pavement to 22 ft by a 2-ft width of 8-in. thick portland cement concrete along each edge, and resurfacing the entire width with a 3-in. thickness of bituminous concrete, Illinois subclass I-11. A typical cross-section of the rehabilitated pavement structure is shown in Figure 3.

The experimental portion of the project consisted of two sections of welded-wire fabric placement and two control sections without fabric. The two sections with fabric included a 2,500-ft section of continuous placement of sheets of several different widths and an 18,000-ft section of intermittent placement in which sheets 10½ ft in width were placed in the 11-ft lanes at 19 severely distressed locations. The 2,500-ft section was subdivided into five equal lengths for placement of the different widths of fabric. In the first four subsections, the fabric was placed successively 3½, 4½, 5½, and 10½ ft wide in the westbound lane. A 10½-ft width was placed in both the east and westbound lanes in the fifth subsection. In the 18,000-ft section, all sheets were 10½ ft in width, the lengths of fabric at the individual locations varying from 6 to 120 ft.

The two sections with no fabric installation included a 3,500-ft length in which the interval between transverse cracks in the existing pavement averaged about 50 ft, and a 3,900-ft section in which this interval was about 13 ft. The latter section was selected as the control for the analysis of transverse reflection cracking because its average crack interval was the same as that in the sections containing the fabric. Details of the project layout are shown in Figure 4.

CONSTRUCTION

All construction in the experimental area preliminary to the placement of the welded-wire fabric was completed in September 1958. This work included bituminous skin patch removal, cleaning and resealing of joints and cracks, construction of many full-depth concrete patches, placement of the portland cement concrete widening, application of the asphalt tack coat, and placement of the leveling binder course.

The welded-wire fabric conformed to AASHO Designation: M55 and consisted of 10-gage longitudinal wires on 3-in. centers and 10-gage transverse wires on 6-in. centers. The fabric was cut from 15- by 10½-ft sheets on the job site as needed into 3½-, 4½-, and 5½-ft widths. The individual sheets of fabric were placed directly over the leveling binder course with the transverse wires in contact with the surface to prevent the tracks of the paving machine from snagging the fabric.

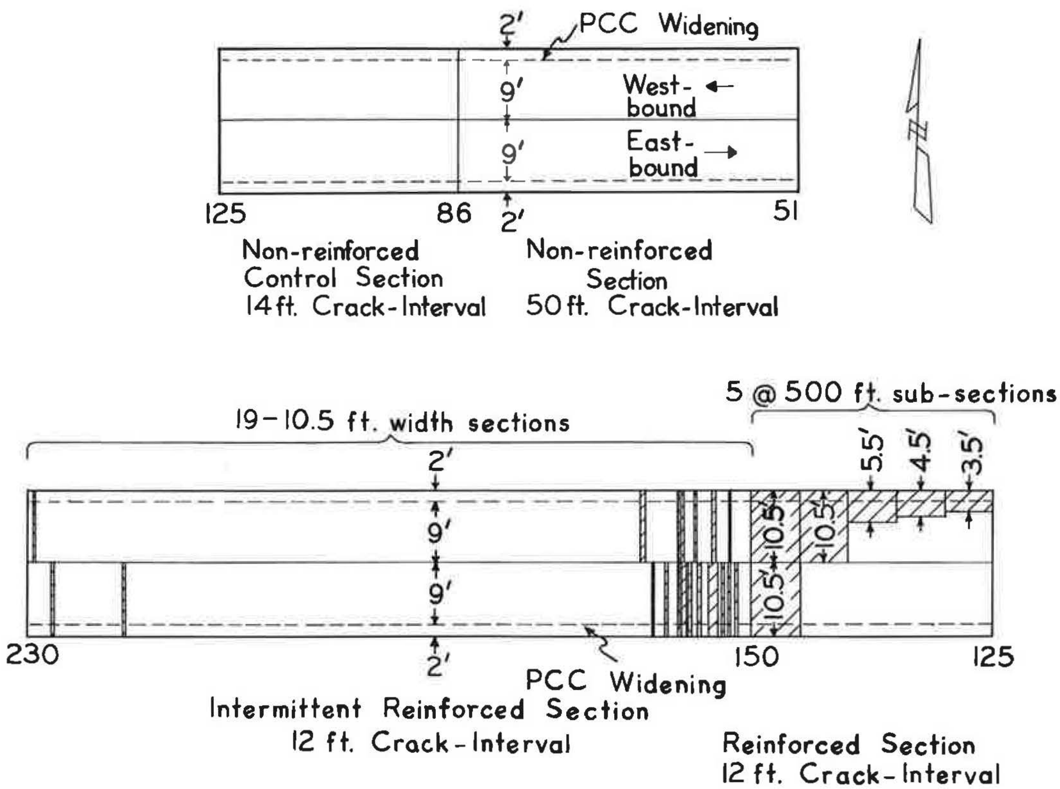

Figure 4. Details of project layout.

The bituminous concrete binder and surface course mixtures were produced in a hot-mix plant and conformed to the Illinois specification for fine dense-graded aggregate type mixtures, subclass I-11. Each mixture was produced from two sizes of a crushed stone aggregate, a coarse sand, a fine blend sand, and a mineral filler (limestone dust) in combination with a 70-85 penetration grade paving asphalt. All material of the binder-course mixture was required to pass a 1-in. sieve opening; all surface-course mixture was required to pass a ¾-in. opening. The leveling binder mixture was the same as the surface mixture.

The mix designs were established by the Marshall method and conformed to Illinois standard design criteria which set a minimum stability value of 1500 and a flow value of 8 to 16. The mix formulas and tolerance limits are given in Table 1.

A special device was developed for holding the wire fabric in place during the placement of the binder course mixture. The hold-down device, a three-runner sled of channel irons, was placed between the tracks of the bituminous paver and pulled along over the fabric by chains attached to special brackets mounted on the paver. In addition, a 9-ft runner of light-weight railroad rail was pulled along outside of each track of the paver

TABLE 1

COMPOSITION OF BITUMINOUS CONCRETE MIXTURES

Material	Binder Course Mixture		Surface Course Mixture	
	%	Tolerance (%)	%	Tolerance (%)
Passing 1-in., retained on ½-in. sieve	34.5	±5	-	-
Passing ½-in., retained on No. 10	32.3	±5	61.5	±3.0
Passing No. 10, retained on No. 200	25.0	±3	28.9	±3.0
Passing No. 200 sieve	4.2	±3	5.0	±1.5
Bitumen PA-6 (70-85 penetration)	4.0	±0.3	4.6	±0.3

to hold the edges of the fabric firmly in place. The sheets of fabric were placed a short distance ahead of the paver so that only the unloading truck needed to drive over them. The positioning of the fabric did not delay appreciably the paving operations.

Spot checks, made by temporary removal of small areas of the binder course to expose the fabric before the rolling operation, revealed that the fabric was tight against the leveling course. At some locations, the fabric was slightly embedded in the leveling course, apparently due to the heat and tamping during placement of the binder course.

Some distortion of the fabric occurred during the installation of the first few sheets of the 4½-ft width. The inside edge of these sheets occasionally curled up between the outside and center runners of the hold-down sled. This curled edge snagged on the cross brace of the sled frame, humping the fabric and causing the spreading screw of the paver to further wrinkle it. This difficulty was eliminated by shifting these sheets inward a few additional inches beyond the normal 3 in. that other sheets were being set in from the edge of the base. This positioned the inner edge of the fabric under the center runner of the sled.

Occasionally, the sheets of fabric were skidded ahead and buckled between the wheels of the unloading truck, particularly on downgrades. This condition was remedied by applying less tension of the truck brakes while the paver pushed the truck during unloading operations. Little difficulty was encountered in placing the binder course over the isolated single pieces of fabric in the areas of intermittent placement.

TRAFFIC

The pavement involved (formerly Ill. 13) has carried a volume of traffic averaging approximately 1,700 veh/day since resurfacing, including about 15 percent commercial vehicles. The volume and character of the traffic traveling in each direction appears to be about equal.

In an effort to present the data in a manner that reveals the most evidence of actual performance, the dependent variable has been compared with length of service and the accumulation of 18-kip equivalent single-axle loads representative of the mixed traffic loadings. Equivalency factors for converting single- and tandem-axle loadings into equivalent 18-kip single-axle application were derived from the AASHO Road Test performance equations (1). The volume and composition of traffic used in this conversion are given in Table 2.

OBSERVATIONS AND MEASUREMENTS

The observations and measurements include (a) a condition survey of the existing concrete pavement made just prior to widening and resurfacing in 1958, (b) annual surveys from 1959 to 1963 of the conditions of the bituminous concrete resurfacing, (c) rut depth measurements taken in the wheelpaths, and (d) road smoothness measurements taken with the BPR-type Illinois roadometer.

Special field sketch sheets were used for each condition survey to show transverse and longitudinal cracking. Prints of the pre-resurfacing survey sheets were used as underlays for the field sheets of the annual surveys of the resurfacing. Therefore, cracks could be tabulated as reflected or as occurring at previously uncracked locations.

Transverse cracks were tabulated and counted as reflection cracks if they extended half-way or more across the lane. Longitudinal reflection cracks were tabulated as continuous if the total length of short intermittent reflected cracks were at least half the potential crack length. The sketched lengths of longitudinal reflection cracking were tabulated to the nearest 5-ft increment.

TABLE 2
TRAFFIC VOLUME AND COMPOSITION

Year	Total Avg. Daily Traffic	Avg. Daily Truck Traffic		Accumulated 18-Kip Equiv. Single-Axle Loads
		Single Unit	Multi-Unit	
1959	1,650	290	10	7,500
1960	1,650	290	10	15,045
1961	1,700	240	10	21,580
1962	1,700	240	10	28,115
1963	1,700	240	10	34,650

The road smoothness measurements were taken during the annual surveys of 1962 and 1963.

Rut depth measurements were taken in the wheelpaths of both lanes in 1962 and 1963. In general, these measurements were made at 500-ft intervals.

ANALYSIS OF DATA

The condition survey of the old portland cement concrete pavement before resurfacing revealed numerous wide transverse cracks and associated spalling and faulting. There were two general transverse crack intervals, one at nearly 50 ft, between Stations 51 and 86, and the other at approximately 10 to 15 ft, between Stations 86 and 230 (Fig. 4). No reason was found for the wide difference in crack interval between the two locations.

The survey data on longitudinal reflection cracking over the longitudinal widening joints were summarized and analyzed for the two sections with fabric and for the two sections without fabric reinforcement. The progression of longitudinal reflection cracking over the widening joint for both the reinforced and nonreinforced sections is shown graphically in Figure 5.

Reflection cracking over the longitudinal widening joint in the areas containing the welded-wire fabric was not apparent until the fourth survey in 1962, at which time 0.2 percent of the total possible length had reflected. In 1963, after 5 yr of service, the reflected amount was still less than 1 percent. Reflection cracking over the widening joint in areas outside the fabric reinforcement, recorded in 1959 after 1 yr of service, amounted to 0.3 percent of the total possible length. In 1960, the recorded value was approximately 10 percent. This cracking distress progressed to 57 percent in the third year of service, to 63 percent in the fourth year, and to nearly 70 percent by the fifth year, 1963. During these years, single-axle loads accumulated at the rate of about 7,500/yr. All widths of fabric reinforcement appear to be about equally effective in controlling cracking over the widening joint.

The analysis of transverse reflection cracking was limited to the two sections of pavement of initial long and short average joint and crack interval when no reinforcement was used, and to the reinforced sections having near-full-lane-width ($10\frac{1}{2}$ ft) fabric. The nonreinforced section of shorter joint and crack interval and the fabric-reinforced section initially had about the same average interval of 13 ft. The other nonreinforced section initially had an average joint and crack interval of about 50 ft. It did not seem appropriate to include in this analysis the sections in which the shorter widths of fabric covered the original transverse joints and cracks only partially. The progression of transverse reflection cracks, expressed as a percentage of the original number of transverse joints and cracks, with time and the accumulation of 18-kip equivalent axle loads is shown in Figure 6. From this figure, it is apparent that the welded-wire fabric has been beneficial in reducing the growth of transverse reflection cracking up to the fifth year of service, with the percentage reflected being about one-fourth that in the 50-ft crack-interval section, and less than one-half the value of the 13-ft crack-interval control section.

It must be pointed out in comparing the two nonreinforced sections that the percentage of transverse cracks reflected is no indication of the over-all surface con-

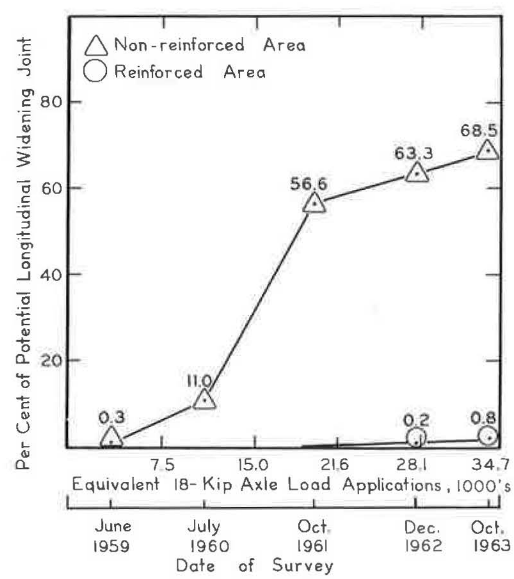

Figure 5. Progression of longitudinal reflection cracking over widening joint.

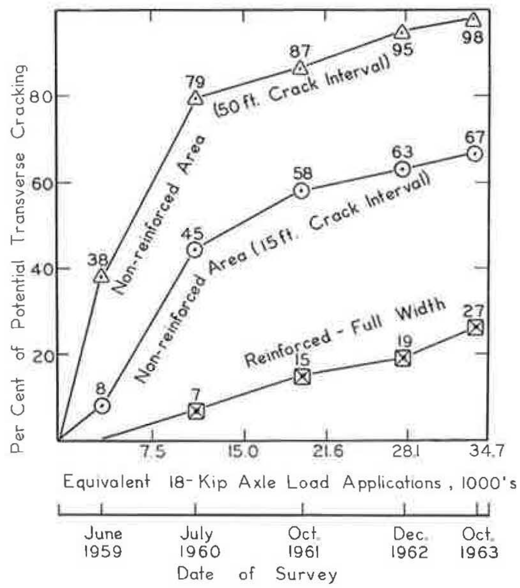

Figure 6. Progression of transverse reflection cracking.

dition of the two areas of pavement because these two areas differ greatly in the average length of uncracked sections, which was 47 ft in the originally longer crack-interval section, 20 ft in the control section, and 70 ft in the continuous full-lane reinforced sections after 5 yr of service.

Smoothness measurements recorded in 1962 and 1963 by the Illinois roadometer have indicated little variation in the riding quality throughout the project. The roughness indices indicated subjective ratings of "slightly rough" in both reinforced and nonreinforced sections. There is no apparent correlation trend that would demonstrate the usefulness of fabric to retard depreciation in the riding quality after 5 yr of service. However, as the cracking progresses to spalling and dislodgement of surface particles, the control of reflection cracking demonstrated to date by the fabric reinforcement may be reflected in the riding quality.

Rut depth measurements up to the fifth year of service, with maximum values less than 0.1 in. on both reinforced and nonreinforced sections, offer no evidence of the effectiveness of fabric to resist rutting or shoving in the bituminous overlay.

DISCUSSION AND FINDINGS

Welded-wire fabric can be incorporated in bituminous concrete resurfacing construction with conventional equipment and without appreciable difficulty. However, some type of hold-down device or a means of securing the fabric to the leveling binder course is required to prevent the tracks and augers of the paving machine from catching in the fabric. During paving operations, the truck driver should carefully control tension on the truck brakes, especially on downgrades, to avoid shifting the wire fabric.

After 5 yr of service under moderate traffic, the welded-wire fabric had practically eliminated the formation of reflected cracks over the longitudinal widening joint and had reduced substantially the reflection cracking over transverse cracks and joints.

The reflected cracks in the areas of no fabric will probably progress to more serious deterioration, as demonstrated by past performance of resurfaced pavements, and, therefore, will eventually affect the riding quality. The degree to which the fabric will be able to control or prevent this progression undoubtedly will provide a real measure of the benefits derived from the use of welded-wire fabric in bituminous concrete resurfacing.

Although this experimental project might eventually provide some definite data regarding the long-term beneficial effects of welded-wire fabric reinforcement, some consideration should be given in future research to incorporating reinforcement in bituminous concrete surfacing over pavements of various crack intervals and stages of deterioration. The inclusion of control sections of various thicknesses of resurfacing to determine possible cost-benefit relationships should also be considered. The cost of the welded-wire fabric installation on this particular project was about the same as the cost of an additional inch of resurfacing thickness.

REFERENCE

1. Chastain, W. E., Sr., "Application of Road Test Formulas in Structural Design of Pavement." HRB Spec. Rept. 73, pp. 299-313 (1962).