Application of Wire Mesh Reinforcement to Asphalitic Concrete Pavement Overlays

Ellis G. Williams
Kentucky Highway Materials Research Laboratory
MEMO TO: D. V. Terrell  
Director of Research

In response to suggestions from the Wire Reinforcement Institute, the Department established during the past construction season some test sections to investigate wire mesh reinforcement in bituminous concrete. As in the case of most similar projects in other states, the intent was to determine the effectiveness of wire mesh for controlling "reflection cracking" in bituminous overlays placed on existing portland cement concrete pavement.

A project for resurfacing U.S. 60 between Frankfort and Shelbyville was chosen for the test, and the Research Division was asked to observe the experimental portions and prepare reports on their construction as well as their subsequent performance. The attached report by E. G. Williams covers the construction.

Two types of mesh were used, and they were applied in three different ways: as continuous reinforcement between a compacted leveling course and the overlying binder course; as continuous reinforcement with mesh placed immediately on top of the existing concrete; and as reinforcement just at the joints and immediately on top of the concrete pavement. The first of these was found best from the standpoint of ease in placement, but of course it is too early to estimate which if any might be of greatest advantage in retarding development of reflection cracks.

By far the greatest problem in paving with mesh reinforcement is holding the sheets in place while the paver and mix trucks operate over them. This difficulty showed up in various ways, including the destruction of several (about 5 percent of the total) mesh
mats that became entangled in the screed of the paver. Even so, progress of the work was not seriously retarded, and some adaptations on paving equipment have been visualized for improving on work of this type. About the only obvious flaw in the completed pavement containing mesh was slight roughness where the reinforcement was placed over joints. This was attributed to greater pre-compaction density of mix spread within the confines of the mesh as opposed to the comparable density of mix placed on the surface of the concrete.

This pavement will be observed at rather frequent intervals during the next few months and at less frequent intervals as time goes on. Results of the experiment will be judged on the basis of initial crack locations which Mr. Williams has recorded on strip maps at the back of his report.

Respectfully submitted,

L. E. Gregg
Assistant Director of Research

LEG:ddc
Copies to: Research Committee
Mack Galbreath (3)
APPLICATION OF WIRE MESH REINFORCEMENT TO ASPHALTIC CONCRETE PAVEMENT OVERLAYS

Franklin-Shelby County Project FI 172 (12)

by

Ellis G. Williams
Research Engineer

Highway Materials Research Laboratory
Lexington, Kentucky
December, 1954
INTRODUCTION

The chief reason for placing wire mesh in a bituminous paving course (or courses) is to reduce or perhaps eliminate transmission of the effects of cracks and joint spaces in the underlying material through the new paving course to its surface. For that reason, wire mesh reinforcement of asphaltic concretes has been applied principally in the resurfacing of old cement concrete pavements.

The first use of this principle was made in Michigan in 1937, when 1.3 mi. of bituminous concrete reinforced with wire mesh was placed over a section of badly broken cement concrete pavement. In this case the purpose was to reduce transmission of cracks (commonly known as "reflection cracking") through the bituminous courses. Observations after seven years service show the reinforced section to be far superior to sections in which wire mesh had not been included.

During the latter part of and after World War II, the Corp of Engineers employed wire in some experimental pavements in an effort to reduce deformation caused by heavy traffic. This work exemplified additional beneficial effects that might be obtained from wire mesh reinforcement.

As a standard bituminous paving procedure, wire mesh reinforcement began in Texas in 1945. All known methods and wire types which had been employed elsewhere were included in the Texas program, and several new methods were attempted. Other State and Federal organizations have experimented with mesh reinforcement since that time, and none has reported unfavorable results in the performance of the completed pavement.
The first use of any type of "reinforcement" for bituminous pavements in Kentucky was made in 1947 when expanded metal mats were placed at the intersection of Jefferson and Third Streets in Lexington*. In this case the principal objective was to reduce shoving. However, results were not satisfactory, and failures occurred normally. It was observed that some failures might have been brought about by the type or form of metal used; therefore, these results did not condemn the fundamental idea.

In the summer of 1954, the Division of Design included 1000 ft. (full width) of wire mesh reinforcement in the resurfacing of US 60 between Frankfort and Shelbyville (See Fig. 1) to permit study of this innovation in asphaltic concrete pavements. The project involved resurfacing a portland cement concrete pavement with 1-3/4 in. of binder and 1-1/2 in. surface - both Class I, Type B bituminous concrete. Prior to resurfacing the concrete pavement was undersealed with an asphalt having a softening point of 175 to 200°F. Slabs that had been badly broken were removed and replaced.

At the request of the Division of Construction arrangements were made to observe and report on experimental features of the project. Principal objectives of the study were considered to be:

1. The effectiveness of wire reinforcement in preventing:
   (a) reflection cracking of bituminous concrete overlying cement concrete pavements, and
   (b) lateral displacement of bituminous concrete pavements when it is subjected to accelerating and decelerating traffic.

* An Experiment With Expanded Metal Integrating Mats in Bituminous Concrete Pavement", a report to the Research Committee, September, 1947.
Fig. 1 - Locations of Test Sections on the Shelbyville-Frankfort Road.
2. To study methods for incorporating wire mesh reinforcement in bituminous concrete pavements.

The present report deals mainly with methods employed in construction of the reinforced sections. Most of the observations which may be considered results at this stage are presented in pictorial form.
LOCATION AND DESCRIPTION OF TEST SECTORS

The locations were selected for reinforcing (See Fig. 1). Each of these was divided into three parts - a reinforced sector adjoined at the ends by two control sectors of equal or greater length. A crack and joint survey was conducted at each of the locations, and these data were recorded on strip maps (See Appendix I) to facilitate future inspections.

Location No. 1, which was in Clay Village, and consisted of a 400-ft. reinforced pavement with 1300 ft. of control pavement. Wire mesh was placed over a leveling course of variable depth and beneath binder and surface courses totaling about 3-1/4 in. in depth. The concrete pavement was badly broken and serious pumping was evident. A section of the old pavement which had been designated for removal was (for experimental purposes) permitted to remain. This location was established to test the effectiveness of wire reinforcement in resisting reflection cracking of bituminous concrete when subjected to severe deflections. If large deflections occurred at the joints in both control and reinforced sections, cracking of the new surface would be expected to occur rapidly.

Location No. 2 was near Peytonia. It consisted of a 1600-ft. intermittently-reinforced sector and two control sectors totaling 8600 ft. in length. Short lengths of wire covered the joints and extended only a few feet on either side. Wire was placed directly on the concrete pavement. This location was intended to provide information pertaining to the prevention of reflection cracking by reinforcement of the joints only.
Location No. 3, at the Half-Way House, consisted of a 400-ft. reinforced sector and control sectors totaling 2340 ft. The reinforced pavement was continuous as in Location No. 1, but the wire was placed directly on the underlying cement concrete. This section provided the opportunity to study resistance to reflection cracking, as well as the effect of wire reinforcement on resistance to lateral displacement. The test sector will be subjected to a large volume of accelerating and decelerating truck traffic entering and leaving the road at the Half-Way House. The presence of a slight grade at this location may tend to exaggerate some results.

Equal quantities of two types of No. 10 gauge welded wire mesh were used, and each test sector contained both types. One type had a 4- x 4-in. opening, the other type a 3- x 6-in. opening as illustrated in Fig. 2. In the case of the latter type, longitudinal wires were spaced 6 in. apart, and transverse wires 3 in. apart. Both types were cut to size from large sheets with the sheets of 4- x 4-in. wire being 8- x 10.5-ft. in size, and 3- x 6-in. wire being 10.5-x 10.5-ft. in size.
Fig. 2 - Examples of the two types of wire mesh reinforcement materials with: (a) 4-x4-in. openings and (b) 3-x6-in. openings. Mats were overlapped in this manner in the direction of paving. Although it is not shown by these illustrations, normally hog rings were used to tie the separate sheets together in order to reduce slippage during paving operations.
GENERAL FIELD OBSERVATIONS

Inasmuch as the test locations were rather widely separated, observations on the project were not carried on continuously. However, Research Laboratory personnel were on the job at all times when materials were being placed in the test locations, and at several other times when samples of the bituminous mix were taken and tests made for purposes having no particular bearing on the wire reinforcement study.

Location No. 1

At Location No. 1 wire mesh was placed directly over the leveling course after it had been completed. An attempt was made to place the wire immediately on loose bituminous mix for the leveling course and then roll it into the loose mixture during the compaction process. However, this procedure was unsuccessful and it was abandoned after only one trial. The reinforcement section at this location was 400 ft. long and contained 200 ft. of each type of wire mesh.

As shown in Fig. 3, wire was laid along the shoulder while the leveling course was being compacted. After rolling was completed the wire was moved laterally to the proper position of the pavement (See Fig. 4). The binder course was then spread over the wire and rolled in the usual manner.

The position of the mesh was such that it laid parallel to the center line and about 3 in. from the outside edge of the leveling course. Successive sheets were overlapped in the direction of paving, but there was no center lap at any point. However, in all cases an attempt was made to cover the center joint of the leveling course by extending wire
Fig. 3 - Position of wire mesh prior to its placement on the compacted leveling course. An attempt to place the wire before compaction of the leveling course brought about very poor results, and was therefore abandoned in favor of the method of first compacting the leveling course, placing the wire mesh, and then spreading the binder course over the wire.

Fig. 4 - Wire mesh correctly positioned on the compacted leveling course. The truck in the background contains binder course mix which will be spread directly over the wire mesh.
mesh from one lane to a few inches beyond the center, and then positioning the wire in the other lane so that the two did not overlap but joined flush, thereby, providing coverage of the center joint.

With this procedure it was necessary that the wire mesh be held down firmly to the leveling course during the application of the binder course. If the mesh was not laid down, it had a tendency to warp under the weight and movement of the paver and mixture (See Fig. 5). Sometimes this deformation was so severe that the wire became entangled on the screed, and a condition such as that shown in Fig. 6 resulted. This difficulty might be explained by the fact that the paver was equipped with a serated, oscillating screed, instead of a tamping screed, and would thereby be more apt to entangle the mesh in the paver. Even when the care described above was exercised several sheets of mesh were entangled and destroyed. Total loss under all conditions of placement in the project was 9 from a total of 195 sheets, or about 4.6 percent.

Prevention of warping of the mesh in front of the paver was recognized early as one of the important requisites for a successful operation. Since the paver itself was not equipped with any device that would hold the wire down, the technique illustrated by Fig. 7 was employed for this purpose. On each side of the paver a workman used a shovel to press the mesh tightly against the leveling course while the second course was being applied. When necessary other workmen would pull central parts of the mesh to eliminate deformations occurring at the center.

The practice of pressing down the mesh with a shovel could have been avoided had the paver been equipped with shoes, either weighted or spring loaded. As a rule, four or five such shoes are essential for an operation of this type.
Fig. 5 - Typical deformation of wire mesh caused by the weight and movement of the paver. This condition was encountered (to various degrees of severity) in all test sectors of the project and was, perhaps, the greatest hindrance to paving operation.

Fig. 6 - Deformation of wire mesh accompanied by entanglement of the mesh in the screed. This event occurred whenever extreme caution in holding down the mesh was not exercised. Note that the entire sheet of mesh has been deformed. Such sheets were necessarily removed and discarded.
Fig. 7 - Technique used in holding down wire mesh to surface of leveling course during application of binder course. Although this procedure helped to reduce the possibility of wire mesh becoming entangled by the screed, it was often necessary for other workmen to straighten the mesh by simultaneously pulling it from opposite sides.

Fig. 8 - Typical appearance of emergent wire mesh. This condition (which, for the most part, was ascribed to inadequacies of the paver) was observed many times during the project, and often involved very large sections of mesh.
When the warping condition was combined with slippage of the front drive wheels of the paver, pronounced bowing of the mesh occurred. If the paver continued in its course, some part of the section of mesh usually appeared on the surface of the binder course, as illustrated in Fig. 8.

Location No. 2

At Location No. 2 the test section consisted of short lengths of mesh placed so that they covered the transverse joints and extended a few feet on either side (See Fig. 9). Twenty-eight joints were reinforced in this manner, six of which were constructed with mesh having 3- x 6-in. openings and the remainder with mesh having openings 4 x 4 in. in size. Sheets of wire mesh were cut in half and each half centered over a joint in the cement concrete pavement.

This method had a definite economic advantage in that a smaller quantity of mesh was required than at either Location No. 1 or No. 3. In addition wire placed in this manner (at the bottom of bituminous courses) was in the best position to offer maximum resistance to downward deflection, and should, therefore, have a strong tendency to offset reflection cracking.

At this location the mesh was not fastened to the underlying pavement and sometimes it was shoved forward by the paver as mix was applied. This condition resulted in the formation of a crack in the mix at the rear of the wire, or at the end toward the rear of the paver. In some cases, these cracks were as much as 2 in. wide and handworking was necessary for their repair and closure. This difficulty might have been overcome by pinning the rear transverse wire (with a Ramset, or similar device) to the concrete pavement.
Fig. 9 - Method of placing wire mesh over transverse joints in the old portland cement concrete pavement. Positioned in this manner, it was decided that the mesh would offer considerable resistance to downward deflection of the bituminous courses above, thereby offsetting tendencies toward reflection cracking.

Fig. 10 - General view of Location No. 3. The Half-Way House (a truck stop) is situated to the left of and beyond the paver in the left foreground. Note that wire mesh is being placed only a relatively short distance in front of the paver, thus minimizing the deforming effects of mix-truck traffic.
A condition first observed at this location was thought to have considerable significance with regard to the general use of this method. Lateral resistance was greater when spreading over wire mesh than when spreading directly over the concrete pavement. This increase in resistance caused the paver to spread a greater quantity of mix per square yard in the reinforced sections, yet the depth of the non-compacted mix was uniform. As a result, the uncompacted density of the course was greater in sections underlain by wire mesh, and when the material was rolled to a uniform density the sections containing mesh was visibly higher than other parts of the pavement. Furthermore, these raised sections were readily noticeable when riding over this location in an automobile. Much of the roughness was eliminated when the surface course was placed, but riding qualities of the pavement were still unsatisfactory.

**Location No. 3**

Except for the placement of wire mesh in direct contact with the concrete pavement, the third method of reinforcement was no different from the first. The test sector contained 400 ft. of continuous wire mesh - 200 ft. of each type.

At this location, as well as at Location No. 1, wire mesh was placed only a short distance in front of the paver. It was found that this practice minimized deformation of the mesh caused by mix trucks backing up to the paver (See Fig. 10).

As in operations at the other test locations, bowing and warping of the wire mesh was a problem, and perhaps it was most prevalent at this location. Since it was more difficult to hold down the mesh (by the
method illustrated by Fig. 7), deformation caused by slippage of the paver, occurred more often here than in the other sections.

Parts of some warped sections of wire appeared on the surface of the leveling course after the paver had passed (See Fig. 11). The affected areas were raked to the proper smoothness before rolling. However, this practice did not help the situation, for when this course was rolled, even more of the deformed mesh had surfaced (See Fig. 12). During rolling, the bituminous mix compacted normally while the mesh apparently remained almost in its original position.

When a section of wire mesh worked upward in the mix to where it was very near the surface of the leveling course at the time of compaction, usually the thin layer of mix above the wire would crack and soon become removed by traffic, leaving portions of mesh exposed. If the wire mesh had been placed between the binder and surface course, and this condition had occurred, removal and patching of the cracked area would therefore have been necessary. This is perhaps the chief reason why it was considered an impractical procedure to incorporate wire mesh between these two courses.

As a rule, the appearance of a rolled pavement reinforced with wire mesh properly imbedded was no different from that of any other similar pavement. However, in some instances hair cracks opened at joints between sheets of mesh (See Fig. 13). Usually these cracks closed under traffic before the surface course was laid. Reports on projects of this type in other states have discussed the occurrence of these cracks and have treated their presence as a normal result of this type construction. In this project, the extent of cracking was minor. A possible
Fig. 11 - Condition caused by extreme warping of wire mesh as paver advanced. This photograph was made just as the paver had passed and hand-raking of the area had begun. The mesh had been bowed upward by slippage of the paver wheels, and wire had become exposed at the surface of the binder mix.

Fig. 12 - Area shown in Fig. 11 after compacting. Although an attempt was made to repair this section by hand-raking prior to rolling, an even greater amount of mesh was visible after the course had been rolled. The mesh remained stationary while mix surrounding it was compacted.
Fig. 13 - Section of leveling course directly above joint between sheets of wire mesh. With some difficulty a crack can be seen to the right of the rod-like object. The actual length of the object is about 3 in., and the hair crack runs for almost the entire length of the section illustrated. Since traffic soon closed these cracks, their presence was considered to be of minor significance.
explanation for this contrast in results might be that in this project a relatively course mix was used in the binder course, thereby reducing the possibility of cracking, which is more often associated with finer-graded mixtures. Since Class I, Type B surface mix is somewhat finer than the corresponding binder mix, probably hair cracking would be more prevalent had the mesh been placed directly beneath the surface course rather than beneath the binder or on the surface of the concrete.
SUMMARY AND RECOMMENDATIONS

Inasmuch as the ultimate performance of pavement containing wire mesh placed in the three different ways will determine whether the use of mesh is desirable, conclusions on its merits can not be made at this time. With regard to the three different methods of placement and other construction features, the following points are significant:

1. From the standpoint of overall paving operations, mesh was placed most effectively over the compacted leveling course just prior to the spreading of binder mix (Location No. 1). Apparently the coarse texture of underlying material helped the wire offer resistance to slippage during application of the binder. However, the leveling course must be compacted before placement of the mesh, otherwise it will deform severely under action of the roller compacting the leveling material.

2. Mesh could be placed satisfactorily immediately over the existing concrete as either reinforcement at joints in the concrete (Location No. 2) or continuous reinforcement (Location No. 3), but difficulties were greater in those cases. In addition, reinforcement at the joints tends to cause unevenness in the finished pavement.

3. Regardless of the method of placement, deformation of the mesh under action of the paver was difficult to control with the type paving machine used (Adnum). As a result it was necessary to hold the edges of each sheet firmly as the paver moved forward. Probably the paver could be modified or given suitable attachments to resist tendencies for the mesh to slip or deform. Some suggested modifications are shown in Fig. 14.

4. If some deformation of the wire mesh is to be tolerated, two courses of asphaltic mix must be placed over the intended plane of the mesh. The depth of binder material will compensate for considerable warping of the mesh, after which the surface course would accomplish complete coverage of any wire that had emerged during compaction of the binder.
Fig. 14 - The two types of hold-down devices illustrated have successfully modified pavers for laying bituminous mixtures over wire mesh. Their use on projects in other states has virtually eliminated entangling mesh in the paver. Device I consists of four equally spaced channels suspended from the front of the paver (Section A-A) and bearing on the mesh just in front of the hopper. Device II is a spring loaded lever type hold-down. Four of these devices are equally spaced along front of the feed hopper.
5. If wire mesh is placed directly on the underlying concrete pavement, operations would be improved through attachment of the mesh to the concrete before the bituminous material is placed. In addition, the sheets of wire should be fastened together at overlaps.

Work on the paving of test sections was completed the latter part of September. Since that time three inspections have been made, the most recent being in mid-November. At that time there were no apparent differences among the three test locations (other than the surface irregularities in Location No. 2 mentioned previously), and no difference between the reinforced and non-reinforced portions at the three locations.
APPENDIX

CRACK SURVEY

of

Portland Cement Concrete Pavement Comprising Control and Wire Mesh Reinforced Sections of U.S. 60 (Frankfort-Shelbyville)
KEY TO SYMBOLS

- Joints in concrete pavement
- Surface asphalt from underseal (Usually PAC-5)

- Cracks
- Bituminous overlay
- Station markings
- Crack designation in each slab

- Portland Cement Concrete Replacement Slabs
- Wire Mesh Reinforcement
Crack Survey
Location No. 3

37

38

39

40

41

42

43

44

45

1065+00

1063+48
Crack Survey
Location No. 2

1063+48

1060+00

1055+00

1060+00

1055+00
Crack Survey
Location No. 2
Crack Survey
Location No. 2

1020+ 57
3"x6"
Cont. Wire

1019+ 96
4"x4"
Cont. Wire

1020+00

1015+00

4"x4"
Cont. Wire
Crack Survey
Location No. 2

Location No. 2
Crack Survey
Location No. 1