Technical Report Documentation Page

1. REPORT No.

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE

Wire Mesh Reinforcement in Bituminous Resurfacing

5. REPORT DATE

December 1955

6. PERFORMING ORGANIZATION

7. AUTHOR(S)

Ernest Zube

8. PERFORMING ORGANIZATION REPORT No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

State of California
Department of Public Works
Division of Highways

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

12. SPONSORING AGENCY NAME AND ADDRESS

13. TYPE OF REPORT & PERIOD COVERED

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Presented at the 35th Annual Meeting of the Highway Research Board Washington D.C., January 16-20, 1956

16. ABSTRACT

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A number of methods have been used in an attempt to prevent or retard this type of cracking. Subsealing or mudjacking of the old concrete slabs has been tried, but has not eliminated the trouble. In many cases the old concrete has been covered with a cushion course of granular material of substantial thickness before placing the new surfacing. In other instances, the thickness of the new surfacing has been increasing in an attempt to eliminate or minimize this cracking.

A more recent and promising method involves the use of some form of wire mesh, laid directly on the existing concrete surface and covered by a bituminous surfacing.

This paper describes an experimental project in which the California Division of Highways in 1954 placed several test sections for the purpose of comparing the relative merits of various types of wire mesh.

An old existing concrete pavement subjected to heavy truck traffic on U.S. 40 and constructed in 1935 was selected for the test site. The pavement was badly cracked, had undergone extensive patching and was to be covered with a 4" contact blanket of plant mixed surfacing.

A total of eight experimental sections were placed, incorporating four types of expanded metal mesh, two types of so-called bituminous road mesh and two types of welded wire fabric.

17. KEYWORDS

18. No. OF PAGES:

47

19. DRI WEBSITE LINK

http://www.dot.ca.gov/hq/research/researchreports/1930-1955/55-02.pdf

20. FILE NAME

55-02.pdf

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

WIRE MESH REINFORCEMENT IN BITUMINOUS RESURFACING

By

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Supervising Materials and Research Engineer

53-02

Presented at the 35th Annual Meeting
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Washington D.C., January 16-20, 1956

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Synopsis

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An old existing concrete pavement subjected to heavy truck traffic on U.S. 40 and constructed in 1935 was selected for the test site. The pavement was badly cracked, had undergone extensive patching and was to be covered with a 4" contact blanket of plant mixed surfacing.

A total of eight experimental sections were placed, incorporating four types of expanded metal mesh, two types of so-called bituminous road mesh and two types of welded wire fabric.

The various experimental sections were separated by control sections containing no wire mesh thus permitting a direct and close comparison between reinforced and nonreinforced sections. Cost comparisons indicate the welded wire mesh to be the least expensive of the various types of reinforcement used.

The final answer as to the economical justification for placing wire mesh will depend upon the amount of retardation of cracking or prolonged life of the surfacing with the various types of reinforcement when compared to the control sections.

Introduction

The problem of what to do about reflection cracks occurring in bituminous resurfacing blankets placed over old P.C.C. pavements has been a subject of much concern and paving engineers have long been seeking a satisfactory solution. These cracks not only present an unsightly appearance, but often develop subsequent spalling which presents a difficult maintenance problem. The cracks may appear at any time from a month up to a few years after construction depending upon the condition of the underlying concrete pavement. Vertical movement of the slabs, commonly referred to as rocking slabs, is the most common cause. Other contributing factors are the type and volume of traffic, particularly heavy truck traffic, the thickness of the new blanket and probably to a lesser degree, at least in California, the temperature differential of the seasons. Fig. 1 shows typical reflection cracking of a thin bituminous blanket placed over old concrete pavement on one of our main roads. This picture bears out the fact that reflection cracking is not entirely due to horizontal movements caused by temperature changes in the underlying concrete, as evidenced by the absence of cracking in the lighter traveled passing lane. In this case it is obviously caused by vertical movements of the slabs under heavy traffic.

A number of methods have been used in an attempt to prevent or at least retard reflection cracking. Subsealing or mud jacking of the old concrete pavement slabs prior to blanketing has been tried and although this process greatly reduced the amount or intensity of cracking, it has not completely eliminated the trouble.

In many cases particularly when the old concrete pavement is badly faulted or broken and structurally inadequate to carry the traffic loads, a blanket of granular material 4 in. to 8 in. in thickness is placed and covered with 3 in. to 4 in. of new surfacing. However, existing curbs and gutters or structures and the additional cost of raising shoulders very often do not permit such a substantial increase in thickness.

In other instances, the thickness of the new asphaltic surfacing has been increased in an attempt to eliminate or minimize this cracking. Even the so-called open graded mixes of the macadam type possessing somewhat more flexibility than dense mixes have been tried but still have not completely solved the problem.

From the varying degree of success obtained by any of the above-mentioned methods it appears that prevention of the vertical movement of slabs caused by the passage of heavy trucks is the most important step towards eliminating or delaying the appearance of reflection cracks. In recent years it has been the standard practice of the California Division of Highways to subseal with asphalt before blanketing any concrete pavements showing signs of movement or pumping of the slabs.

It is of interest to note that bituminous blankets placed on many miles of old broken concrete pavements which were built in the early 20's without expansion or contraction joints (but which during the years of service have developed random cracks) are usually free from reflection cracking. This is also true of the pavements covered with the granular cushion courses.

One of the more recent and promising proposals for eliminating or diminishing the number of reflection cracks is the use of some type of wire mesh reinforcing laid directly on the concrete slab or placed between the leveling and surfacing courses of the bituminous blanket. Although the first attempt to use such material was apparently made in Michigan in 1937, it was not until after the last World War that the use of some form of wire mesh became more widespread. In 1946 the State of Texas placed two projects involving the use of so-called wire fabric and reports from Texas engineers indicate that this method apparently reduced crack formation. Since that date numerous experimental installations of welded wire fabric have been placed in various States and reports in general indicate favorable results in crack suppression.

Another form of wire mesh is expanded metal sheets of small diamond size mesh which are used to cover only the individual joints and cracks in the existing concrete pavement. This method of treatment was developed in England, where a number of test sections were placed in 1951. Reports received in 1953 indicate that this application shows a definite promise of delaying or materially reducing the amount of cracking.

It might be well to outline briefly the types of wire mesh that have been used in the various trial installations both in the United States and England.

The two primary types of wire mesh are known as expanded metal mesh and welded wire fabric. The expanded metal mesh is produced by feeding stock sheets into a machine which cuts and expands the solid sheet into a diamond shaped mesh. The diamonds vary in size from 1/4 - by 1-in. to 6- by 12-in. and the gauge of metal can also be varied. The sheets with the smaller sized diamonds are usually cut into 4- by 8-ft. size and are used in building construction for open partitions, door panels, shelving, etc. The larger sized diamond mesh is used for reinforcement in concrete construction work and may be secured in sheets as large as 12- by 16-ft. The small diamond mesh sheets are normally produced with the long dimension of the diamond parallel to the long axis of the sheet, whereas the large diamond mesh is produced with the long dimension of the diamond at right angles to the long dimension of the sheet. Welded wire fabric is produced by spot welding wires to form rectangles. These sheets may have openings of 3- by 6-in. or 6- by 6-in. or any other dimension desired by the consumer. The gauge of the wire may also be varied, and rolls containing up to 300 ft. are available. However, the majority of the installations have been laid with sheets 11 ft.-6 in. wide by 8-ft. long.

This paper describes three experimental projects which were installed by the California Division of Highways in three different highway districts in which various types of wire reinforcement were used. The report describes primarily the installation and problems encountered in the major installation in District X where eight different types of wire mesh were used. The other two installations, of a minor nature and mentioned briefly, involved the use of welded wire fabric only. The project in District VI used wire fabric in rolls each containing 200 ft. which were placed in 6 ft., 12 ft. and 18 ft. widths. The wire fabric installation in District V was covered with bituminous pavement varying in thickness from 2-1/2 in. to 8 in. and thus should provide some information on the relation between reflection cracking and thickness of plant mixed surfacing. In all cases the wire mesh was placed directly upon the old concrete pavement.

Road X-Sol-7-G

The test section is located near the town of Vallejo on US 40, the main arterial between Sacramento and San Francisco, a four lane heavily travelled highway. The average daily traffic count is about 20,000 vehicles with about 15 percent of heavy truck traffic.

This installation, involving a number of different types of wire mesh, was completed in June 1954 under Contract 55-10TC2. It is a rather complete test section in that all of the recommended types of wire mesh were placed under similar construction conditions and in areas where the existing pavement was of the same general nature in respect to amount and severity of cracking. The test sections involved the travel and passing lanes of the westbound travel way only.

The existing 20 ft. wide concrete pavement, constructed in 1935, had been mud jacked and later subsealed with asphalt and some bituminous patches had been placed by the Maintenance Department in past years.

As the old pavement showed signs of vertical movement, the contract provided for subsealing the existing slabs again with hot asphalt. Before resurfacing, the travelled way was widened with cement treated base to provide a standard 24 ft. cross section with full paved shoulders. This widening resulted in a 2 ft. shift of centerline. The resurfacing consisted of 3 in. of plant mixed surfacing, 1/2 in. maximum size aggregate, placed in two layers and topped with 1 in. of open graded mix, 1/2 in.

maximum aggregate. The grading of the bituminous mix conformed to the specifications shown below:

Sieve Size	Percent Passing Dense Graded	Open Graded
1/2 in.	95-100	100
3/8 in.	75-90	90-100
No. 4	50-70	35-50
No. 8	35-50	15-32
No. 16	-	0-15
No. 30	15-30	-
No. 200	4-7	0-3

A careful crack survey of the existing P.C.C. pavement was made and the location of the various test sections laid out. Alternate control sections without reinforcement but showing similar cracking were provided so as to permit ready comparison with each test section. Figs. 2 and 3 are typical of the condition of the old concrete pavement and Fig. 4 shows the general layout of the test sections.

The following forms of wire mesh were used in the test sections:

Type	Mesh Size
Expanded metal	1/2 in. by No. 20 3/4 in. by No. 16 3/4 in. by No. 13 1-1/2 in. by No. 16
Bituminous Road Mesh	3-12-30 (3- by 8-in. diamonds) 6-36-20 (6- by 12-in. diamonds)
Welded Wire Fabric	3- by 6-in. -10/10 gauge 6- by 6-in. -10/10 gauge

Fig. 5 illustrates the comparative sizes of the various types of metal used.

Expanded Metal

The expanded metal was delivered to the job site in 2 ft. and 4 ft. wide strips by 8 ft. long. As the expanded metal is rather expensive the two and four foot wide sheets were being tried in order to determine the most economical size which would prevent crack formation. The 8 ft. long sheets were satisfactory for the passing lane as 8 ft. of old concrete pavement remained due to a shift of the centerline. For the 12 ft. wide travel lane some sheets were cut in half and an 8 ft. and 4 ft. long sheet used, allowing an overlap of about 3 in. All joints such as expansion and contraction joints and random cracks of the slabs were covered with the metal. Short sections of the longitudinal joints between the old concrete and new cement treated base were also covered with 2 ft. and 4 ft. wide sections of the metal, see Fig. 10.

The variation in the random crack patterns, encountered mainly in the travel lane, required a great deal of fitting and cutting of the sheets. In a number of cases, a random crack could not be entirely covered with a 2- by 8-ft. sheet and required the use of 4- by 8-ft. sheets.

The sheets were securely fastened to the old pavement by means of a standard stud driver, see Fig. 7. In this operation a stamping disc, 2 in. in diameter was laid on the metal mesh, taking care to center the disc approximately in the center of the diamond. The operator, after loading the gun with the correct stud and cartridge, placed the gun over the disc and fired the charge. The stud penetrated the disc and concrete, and pulled the mesh into tight contact with the pavement. After a few trials it was decided that a stud having an over-all length of 1-15/32 in. was best suited. A heavy charge cartridge No. 832 was used in order to secure the required penetration. Satisfactory anchorage was obtained in the cement treated base by using a stud having an over-all length of 2-31/32 in. and a light No. 232 powder charge, See Fig. 6.

The 1/2 in. by No. 20, 2 ft. wide sheets were placed first to determine proper stud spacing. The 8 ft. long sheet was fastened at both the leading and trailing edges with about 5 studs and also at a number of spots on either side of the joint.

On passage of the paver over the sheets it was noted that a definite vertical bow appeared in the sheet immediately after the paver treads moved onto the leading edge. It was not possible to determine if the sheet returned to its original shape after the paver moved past. There were no indications of distress caused by failure of the studs to hold the wire in place, as far as longitudinal movement was concerned.

Immediately after the first roller pass, transverse cracking appeared in the mix over the expanded metal sheets. This cracking became more severe on the final roller pass, although the metal was tight against the pavement as determined from the protruding edge of the sheet. On a number of sheets a very definite bump was present, mainly at the leading edge. Generally cracks appeared over both the leading and trailing edges and in a number of cases there also were three or four transverse cracks spaced about 5 in. apart. However, the next morning after approximately fifteen hours of traffic most of the cracks had healed, although the leading and trailing edge cracks were still noticeable.

It was then decided to fasten the sheets only at the leading edge and to determine the least number of studs necessary to hold the sheet in place. Various numbers of studs were used including the absolute minimum for an 8 ft. long sheet, one at each corner and one in the center of the leading edge, see Fig. 8. This proved to be satisfactory and resulted in a considerable saving as each stud in place costs about $.25.

Stud driving operations proved quite successful in the passing lane, with very few failures due to shattering or excessive penetration. Some difficulties were encountered in the travel lane where the concrete appeared to exhibit marked variations in degree of hardness. In numerous instances the stud would penetrate only one-half of its normal distance, or would bend and shatter the concrete, or the charge would drive the stud completely through the disc necessitating the driving of additional studs.

There was no difficulty in the paving operations in any of the expanded metal sections. None of the sheets, including those fastened at the leading edge with only three studs, were torn loose by either truck or paver movement. It was noted that some longitudinal movement on a large number of sheets occurred under the traction stresses of the paver. This movement was in the same direction as the forward movement of the paver and was about 1/4 in. to 1 in. for the 3/4 in. diamonds and 1 in. to 1-1/2 in. for the 1-1/2 in. diamonds. This movement undoubtedly was caused by the forward shifting of the entire sheet, until the studs which were fired in the center of the diamond encountered the edge of the metal.

The rather severe cracking following rolling as noticed in the beginning, where both leading and trailing edges were fastened, was not noted where only the leading edge was fastened. Paving and rolling operations were normal and very little cracking, following rolling, was noted.

The best size of diamond from the construction viewpoint, appears to be either the 3/4 by No. 16 or the 3/4 by No. 13. The lighter stocks were harder to handle and more difficult to fasten securely. The 3/4 by No. 13 in both 2 ft. and 4 ft. wide sheets was easiest to lay and showed the least movement under paver traction forces. However, the 1-1/2 by No. 16 can be laid and if it retards the cracking as efficiently as the 3/4 by No. 13 then the lighter metal would be the most advantageous from an initial cost standpoint.

Bituminous Road Mesh

The bituminous road mesh was delivered to the job in sheets measuring 11 ft.-6 in. in width and 8 ft. in length. The sheets (3- by 8-in. diamond) were laid along the median strip at various locations in the 600 ft. test section and placed continuously on the pavement as needed. Due to widening of the pavement, as mentioned before, the wire mesh extended 4 ft. over the cement treated base in the passing lane. Only 20 sheets of the large, 6- by 12-in. diamond mesh were laid.

The leading edge of the first sheet was securely fastened to the pavement through the use of the stud driver, at about 1 ft. intervals. All succeeding sheets were lapped one diamond, taking care that the sheets in place always overlapped the sheet being laid. The next operation was the fastening of the individual sheets to each other. This was done by two men, each equipped with a supply of medium sized hog rings and a hog ring clipper, see Fig. 6. About four to five rings were used at each lap, the wires being tied along the length of the diamond. The first diamond on each edge of the sheet was always fastened as well as two or three diamonds in between. The hog rings, when crimped into lock position, do not rigidly clamp the wires together and the rings could be freely moved in a longitudinal direction. Vertical movement, however, is restricted to a large extent. The 3-12-30 mesh laid very flat against the pavement and there was very little curl or raised areas along the entire 600 ft. section.

In order to pave over the large sheets it was necessary to provide sleds which forced the sheet to remain flat during movement of the paver. These sleds were fastened to the front of the paving machine and dragged over the sheets just in front of the auger feed. Fig. 13 shows the sleds just before being attached to the paver. A total of five sleds were used, each 9 ft. long. The sleds used on the outside of the Barber-Greene tracks consisted of regular 60 lb. railroad rails. The three sleds placed between the tracks were especially constructed from heavy bar stock to a total height of 2 in. in order to fit under the paving machine. See Fig. 14 for details of sleds.

No particular difficulty was encountered with paving over the bituminous road mesh, except on a curve when due to the uneven traction of the paving machine a slight shifting of the mesh occurred and in one instance some of the wire for a distance of about 30 ft. lifted suddenly out of the leveling course and had to be removed. After proper co-ordination of the truck driver and paving machine operator no further trouble was encountered. Occasional transverse cracks formed almost at once following the paver and in some cases after the first roller pass. Most of these cracks appeared at the laps of the sheets but were ironed out in the final rolling. However, the few that remained on opening the level course to traffic, had healed after overnight traffic. Some of the leveling course mixture was removed, after the rolling, in order to determine the location of the wire. The mesh in all cases was within 1/4 in. of the concrete pavement.

Welded Wire Fabric

This material was delivered to the job in sheets measuring 11 ft.- 6 in. wide and 8 ft. long. Laying operations were the same as previously described for the bituminous road mesh. The fabric was laid so that for the 3- by 6-in. mesh the 3 in. spaced wires were transverse to the direction of travel and the longitudinal wires were uppermost. The first sheet was securely fastened to the pavement at about 1 ft. intervals. Each sheet was overlapped 6 in. and tied on the longitudinal wires only with hog rings. These sheets, having a 1 in. projection of wire, seemed easier to lap than the bituminous road mesh and had less tendency to catch. Generally, the wire laid quite flat, although in some areas the sheets were raised from 3 in. to 4 in. due to warping of the wire above the pavement prior to paving operations. While laying this first section of welded wire fabric it was believed that the movement of the wire ahead of the paver would begin to accumulate enough forward longitudinal movement to cause buckling of the sheets. Therefore, as an experiment, it was decided to secure the leading edge of a sheet about every 150 ft. The overlapping sheet at this point was left free. The idea here was to take up all longitudinal forward movement of the previously laid sheets at this free joint. Close observations during paving operations did not disclose any marked movement of the sheets and any such small movement as occurred was taken up at the individual laps. We, therefore, concluded that this precaution would not be necessary in any future operations.

There were no difficulties in laying the mix over the section and the sleds appeared to iron down the mesh in an excellent manner. Cracking of the mix was very similar to that encountered with the bituminous road mesh. There were occasional transverse cracks, mainly at the laps, which appeared immediately after the mix was laid. Most of these tended to iron out after the final roller pass and the remaining ones had healed after overnight traffic. Removal of the mix in numerous locations along the 600 ft. section indicated that the fabric was about 1/2 in. to 3/4 in. above the concrete pavement. The surface course was placed without any difficulties and no cracks of any kind were noticed.

Crack Survey

Three detailed surveys have been made of the job since its completion in June 1954. The first, in January 1955, revealed a few fine short transverse cracks in the nonreinforced control sections and none in any of the wire mesh sections. The second survey in May 1955, after eleven months of traffic, did not show any material change and no crack over 6 ft. long. The latest survey, made in December 1955 revealed slightly more transverse cracking in the control sections, two cracks extending over the entire width of 20 ft. of the old pavement. No transverse cracks of any kind were visible in the wire mesh sections. Therefore, as of this date no conclusions can be drawn except that so far there is no difference in the relative abilities of the various types of wire mesh to prevent or retard reflection cracking.

At this later survey, however, considerable longitudinal edge cracking was noticed in both the travel lane and passing lane. This cracking extended along the joint between the old concrete pavement and the newly laid widening strip of cement treated base. As none of the longitudinal edge along the travel lane was covered with wire mesh this cracking is irrelevant as far as the wire mesh is concerned. However, in the passing lane which is underlain only with 8 ft. of old P.C.C. due to a shifting of centerline, the 8 ft. long expanded metal sheets placed over the joints were laid to the edge of the old pavement only. The bituminous wire mesh and welded wire fabric, however, extended the full width of the new pavement and covered 4 ft. of the new cement treated base. It was noted that no longitudinal cracking occurred over the joining edge which was covered with the bituminous road mesh or welded wire fabric. The total length of the project is 8,320 ft. Of this distance, 6,540 ft. or 78.6 percent consisted of the nonreinforced edge and 1,780 ft. or 21.4 percent is covered with metal. Approximately 1,200 ft. comprising 18.3 percent of the nonreinforced edge section has developed longitudinal cracking. It appears that up to this time the bituminous road mesh and welded wire fabric has definitely prevented longitudinal cracking.

Cost Analysis

It is difficult to present an accurate cost analysis where a number of relatively short test sections are involved. The installation of the various types of wire mesh was not part of the original contract and was performed under "extra work" and, therefore, no bid prices are available. However, an attempt has been made to present a cost comparison based on our observations during construction and cost figures supplied by the resident engineer. Labor costs, transportation and unloading costs and the price paid for construction and installation and of the sleds all tend to reflect somewhat higher prices due to the short test sections. The final analysis is based on the cost of mesh per square yard of pavement. This method was selected as the only way that a true cost comparison could be made between the small diamond sheets which covered the individual joints and cracks only, and the wire mesh which covered the entire pavement.

Three tables showing analyses for different conditions are presented. Table 1 shows the actual cost of the metal reinforcing on this job calculated on the basis of square yards of pavement covered. The 6- by 6-in. welded wire fabric appears the least expensive with the large diamond bituminous road mesh only slightly higher in cost. As the handling and installation of these two types of metals are similar, the final cost depends primarily upon the original price of the metal. The cost of the expanded metal per square yard of the pavement is noticeably higher and is greatly influenced by the number of random cracks and the cost of fastening.

A direct cost comparison between the small diamond expanded metal sheets and the mesh which covers the entire pavement is difficult to make. On a pavement exhibiting little random cracking and where only the expansion and contraction joints would be covered, the cost of the expanded metal would be greatly reduced. A relative comparison may be obtained by assuming various conditions of the concrete pavement as shown in Table 2. In Case I the joints only are to be covered whereas Case II assumes the coverage of at least one random crack per 15 ft. slab. The cost figures are based on the actual installation costs as shown in Table 1. The first assumed condition indicates that the 2 ft. wide expanded metal sheets are less expensive than mesh which covers the entire slab. In the second assumed condition where one additional crack per slab is to be covered, the cost of the expanded metal is exactly doubled and exceeds the cost of the bituminous road mesh and welded wire fabric. The cost of the 4 ft. wide sheets, of course, is considerably higher. As badly cracked concrete pavements very often have more than one random crack per slab it would appear from this analysis that the cost of covering these cracks with expanded metal sheets of either 2 ft. or 4 ft. widths would be prohibitive. On the other hand, the cost of the other two types of wire mesh which cover the entire pavement remains the same regardless of the number of random cracks.

In Table 3 a cost comparison, for the same specific conditions of the pavement as shown in Table 2, has been calculated in terms of cost per mile for a 24 ft. width of pavement. For further comparison the cost of adding an increasing thickness of plant mixed surfacing is included at the bottom of the table. The cost of P.M.S. is based on average bid prices current in California. Roughly, the cost of either the large diamond bituminous road mesh or the 6- by 6-in. welded wire fabric is equal to the cost of 1-1/2 in. thickness of plant mixed surfacing.

As stated, the cost comparisons presented are approximate only. There is little doubt that large scale installations of any of the wire mesh types described, together with experience gained by contractors, should show an appreciable reduction in cost.

VI-Ker-138-A,B

This installation involved the use of welded wire fabric, and was placed in May 1954 under Contract 55-6VC1. The job consisted of resurfacing 13 miles of old concrete pavement with 3 in. of plant mixed surfacing using 85-100 penetration grade paving asphalt. The old concrete pavement was very badly broken and had been extensively patched. Fig. 25 shows a typical view of the old pavement.

The test sections involving the wire mesh consisted of a number of short sections varying in length from 100 ft. to 500 ft. and with varying width of wire fabric as shown in Fig. 24.

The wire fabric used was 6- by 6-in. x 10/10 gauge wire which was delivered to the job in 200 ft. rolls 6 ft. wide. Three different methods were used in placing the wire directly on the concrete prior to laying the leveling course, which was laid by means of spreader box and blade.

1. An entire roll was laid on the pavement and unrolled with the longitudinal wires uppermost. The leading edge was then tacked down with 1-1/2 in. wire staples driven into the cracks. This method of fastening was not very successful. Only about 1/2 in. of penetration could be secured and many of the staples bent over. They also were easily forced out by movement of trucks over the wire.

2. A roll was cut into 16 ft. lengths which were then overlapped one square and interlocked by bending over the cut ends of the mesh. A portion of this section was also stapled while the remainder was not fastened.
3. The roll was unrolled on the pavement and the leading edge was stapled to the pavement or fastened to the previously laid wire. The other end of the roll was placed between two 2- by 6-in. planks which were fastened together. A chain was attached to the planks and tied to a truck, which applied tension to the sheet during paving operations.

No material change was made in the spreader box, except to round the leading corners of the bottom plates. The trucks were backed over the wire mesh to the spreader box and hooked on. All truck movements were at very slow speed especially during any turning movements on and off the mesh. After the windrow was laid a winged blade of 10 ft. width was used to spread the mix. Two passes of the blade completed the spreading operations of the leveling course. The surface course was spread in the conventional manner with a Barber-Greene Paving Machine.

Of the three methods tried it appeared that the one involving the use of a tension device was the most satisfactory. This method also has been reported as giving good results on a recent large scale installation in Texas, involving the use of 300 ft. rolls of 6- by 6-in. -10/10 welded wire mesh.

A survey made in December 1955 after 1-1/2 years of traffic did not disclose any evidence of transverse cracking in the test sections nor adjacent control sections. However, there were signs of longitudinal cracking in some of the control sections, but none in the wire sections.

V-SB-2-D,C

This test section was laid in March 1955, on Contract 54-5VC12. On a portion of this contract a short section of the old existing P.C.C. pavement was covered with 8 in. of cement treated base and 4 in. of plant mixed surfacing. The adjacent pavement on either end was left in its existing condition, thereby requiring the construction of two tapered transitions involving a varying thickness of plant mixed surfacing as shown in Fig. 28.

A number of sheets of 6- by 6-in. - 10/10 gauge welded wire fabric were placed in both lanes of one of the transitions while the other was allowed to remain as a control. This trial section, although small, should provide some information on the relation between reflection cracking and thickness of plant mixed surfacing over the wire fabric. An attempt was made to secure the minimum thickness of plant mixed surfacing at one end of the tapered section by laying the wire up to the "feathering" point for the leveling course. This resulted in a minimum thickness of 2-1/2 in. of surface course over the wire mesh.

The sheets were laid directly on the existing P.C.C. pavement and lapped one square and then tied with hog rings every fifth or sixth square. The leading edge of the first sheet was secured to the existing P.C.C. pavement by means of a stud driver in order to prevent the spreader box from catching on the first sheet. A light asphalt emulsion tack coat was placed after the wire was laid. However, the amount used was not sufficient to coat the wire and little protection from rusting may be expected.

The leveling course was laid with a spreader box and a blade. No difficulties were encountered, however, the equipment including trucks should be carefully handled while on the fabric. The surface course was laid in the conventional way with a Barber-Greene Paving Machine.

A survey was made in December 1955 after nine months of service. The tapered control section, containing no wire mesh, showed transverse cracking at the thin end over the first two joints. The other tapered section, containing the wire mesh, exhibited transverse cracking at all joints from the beginning of the taper to the start of the wire mesh where the pavement was about 2-1/2 in. thick. No cracking was noticed in the wire section.

Summary and Conclusions

The three types of wire mesh used and described in this report can be laid and paved over by conventional construction equipment without undue difficulty. The plain expanded metal placed over joints and cracks only, required no modification of equipment. The bituminous road mesh and welded wire fabric required some type of hold-down device in order to press the wire flat against the old pavement and prevent the tracks of the paving machine from catching in the mesh. On pavements that are badly cracked or extensively patched it would appear that the use of wire mesh which covers the entire pavement would be more feasible and economical than the use of individual sheets placed locally over the joints and cracks only. Care should be taken in transporting and handling these sheets. The flatter the sheets, the less difficulty will be encountered with springiness and resulting cracking of the mix after placing. Any twisted or kinked sheets should be discarded. When paving on curves the paving machine operator should carefully control the traction of the paver so as to avoid shifting of the wire mesh.

The cost analysis indicates that the welded wire fabric is the least expensive of the various types of metal used. The large diamond bituminous road mesh can be considered competitive with the welded wire fabric and the 2 ft. wide sheets of the expanded metal when placed over expansion or contraction joints only. The cost of the continuous wire reinforcement is equal to about 1-1/2 in. thickness of bituminous surfacing.

A few transverse cracks have appeared in the control sections of the various installations but none in the wire reinforced sections. At this date there is insufficient evidence to form an opinion regarding the effectiveness of the various types of wire mesh used in preventing or retarding reflection cracking. There is, however, definite evidence that the wire reinforcement has prevented the formation of longitudinal cracks.

Although these experimental sections should eventually provide some very definite data regarding the beneficial effects, if any, of the various types of wire reinforcement to prevent or retard reflection cracking, it would appear that in any future installations thought should be given to incorporating one or two other variations such as: Vary the thickness of surfacing from perhaps 2 in. to 4 in. in the reinforced sections and in certain control sections increase the thickness of the bituminous mix so that the price per square yard of the nonreinforced portion is equivalent to that of the wire reinforced section. There is evidence that an increase in thickness of bituminous surfacing may not entirely prevent reflection cracking but the magnitude or severity of such cracking may be greatly delayed and reduced. This is demonstrated to some extent by the pavement represented by Fig. 1 where a 1 in. blanket began to show reflection cracking after 30 days when compared to the District X job where the 4 in. of bituminous surfacing in the control sections has shown practically no reflection cracking so far. Traffic is similar in both cases. Another variation might be to place, prior to resurfacing, a cushion course of granular material varying perhaps in thickness from 4 in. to 6 in. over the old pavement and compare the cost and effectiveness with the wire reinforced sections. One other alternative might be to add rubber in various proportions to the bituminous mixture as a possible method of reducing reflection cracking.

Acknowledgments

The work described herein was performed under the general direction of Mr. F. N. Hveem, Materials and Research Engineer, California Division of Highways. Excellent cooperation was extended by the Resident Engineers of the three test sections, Mr. L. E. Daniel of District X, Mr. N. H. Green, District VI, and Mr. C. L. Bunce of District V.

The writer wishes to especially acknowledge the efforts of Mr. John Skog who took care of most of the detailed work and assisted the resident engineers during the placing of the various wire test sections.

FIG. I
Typical Reflection Cracking.
Both lanes resurfaced June 1954 with 1-in. thick bituminous mix.
Note absence of cracks in passing lane at left.
Cracks began to appear after 1 month.
US 40 near Fairfield

District X-Sol-7-G
Condition of Old Concrete Pavement

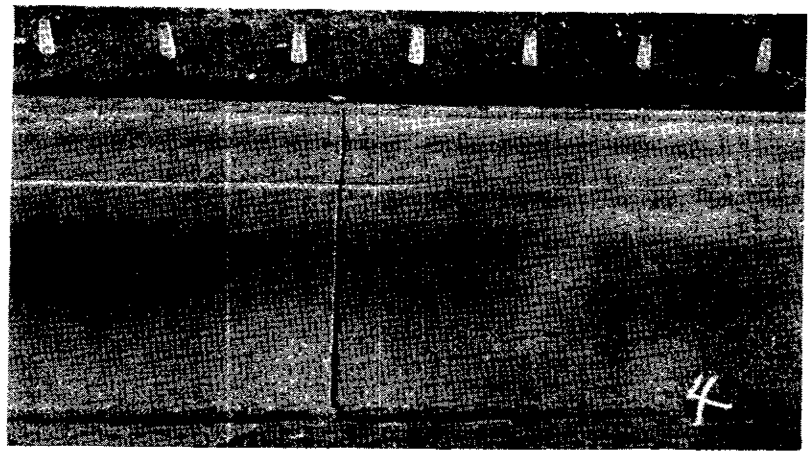


FIG. 2
Joint
Note hole for subsealing.

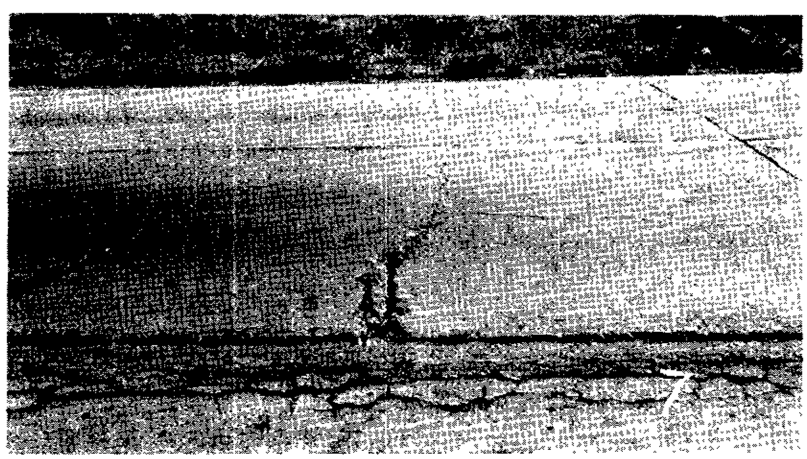
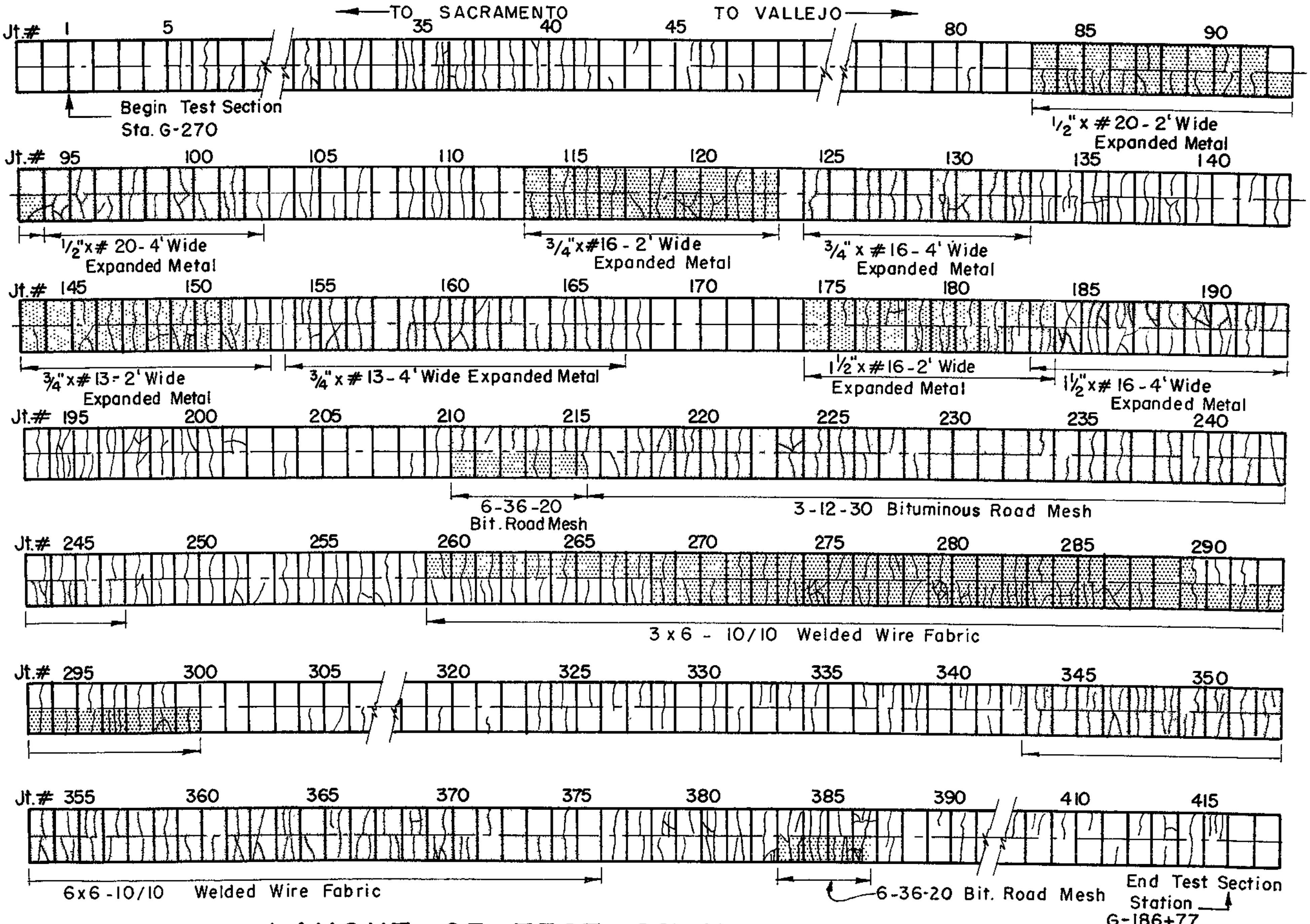


FIG. 3
Random Cracks



LAYOUT OF TEST SECTION - X-Sol-7-G

Fig. 4

Type	Designation	Relative Size
Expanded Metal	1/2" x #20 3/4" x #16 3/4" x #13 1 1/2" x #16	
Bituminous Road Mesh	3 - 12 - 30 3"x8" Diamond 6 - 36 - 20 6"x12" Diamond	
Welded Wire Fabric	3" x 6" 10/10 Gauge 6" x 6" 10/10 Gauge	

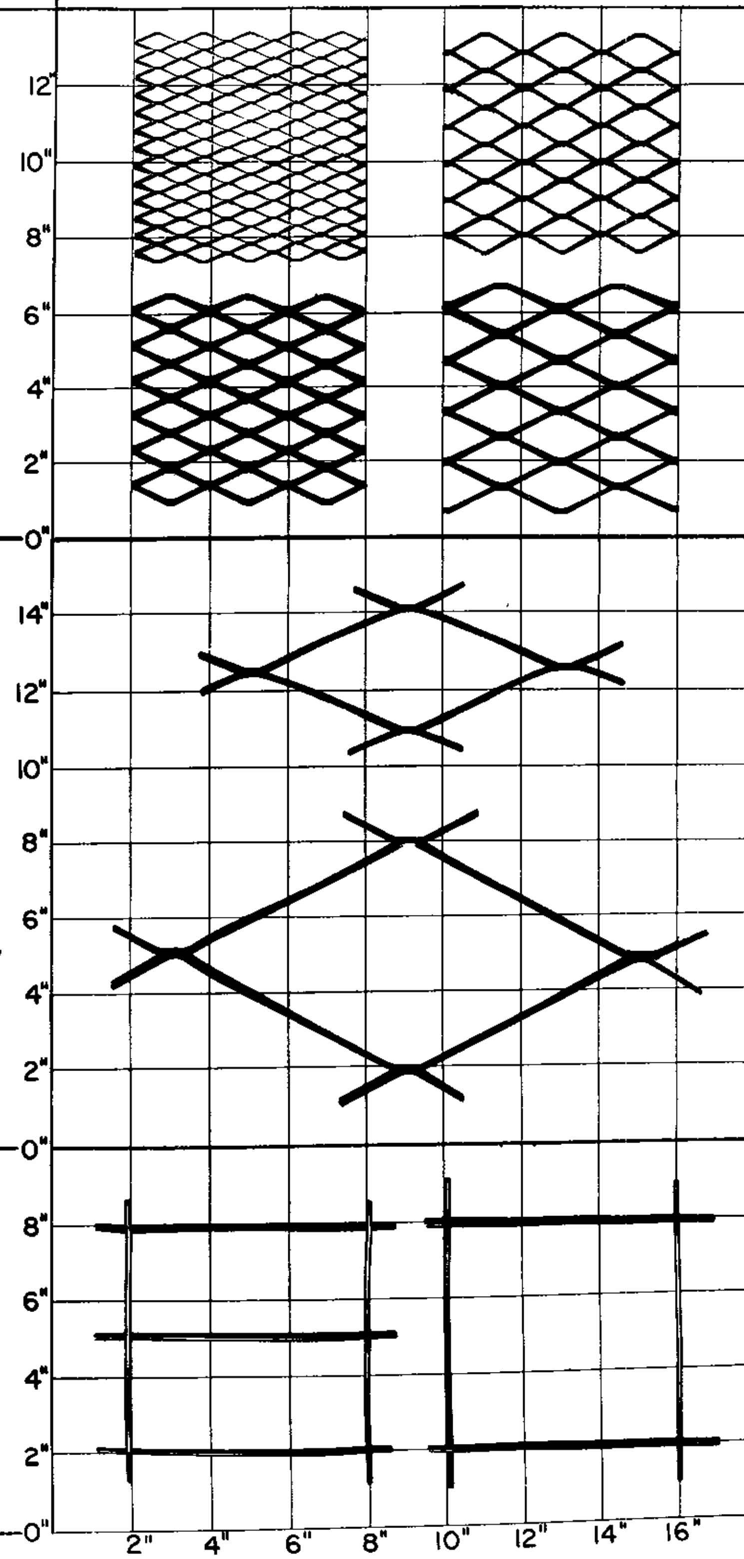


FIG. 5

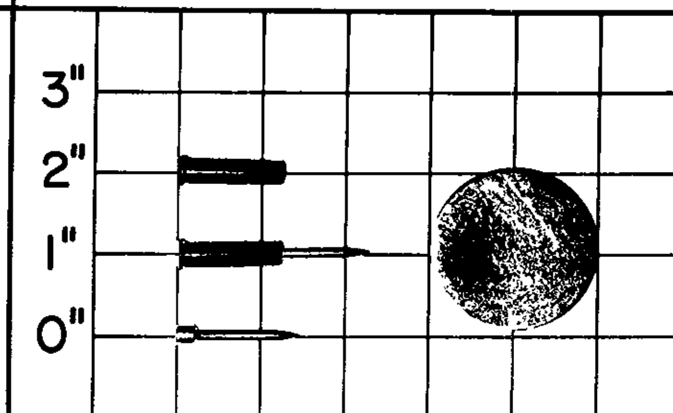
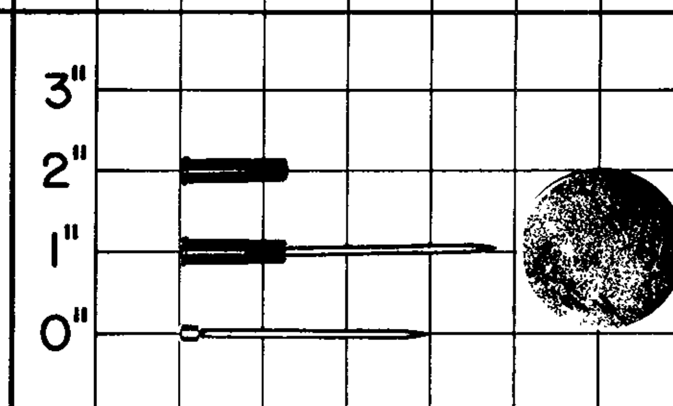
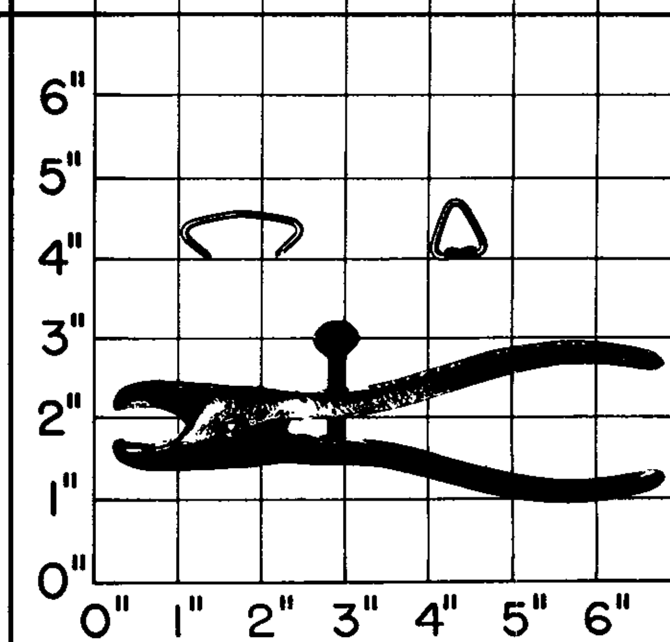
PURPOSE	DESIGNATION	RELATIVE SIZE
To Secure Expanded Metal Sheets To P.C.C. Pavement	Cartridge Stud And Disk	
To Secure Expanded Metal Sheets To Cement Treated Base	Cartridge Stud And Disk	
For Fastening Laps Of Bituminous Road Mesh And Welded Wire Fabric	Hog Rings And Fastening Equipment	

FIG. 6

District X-Sol-7-G
Expanded Metal

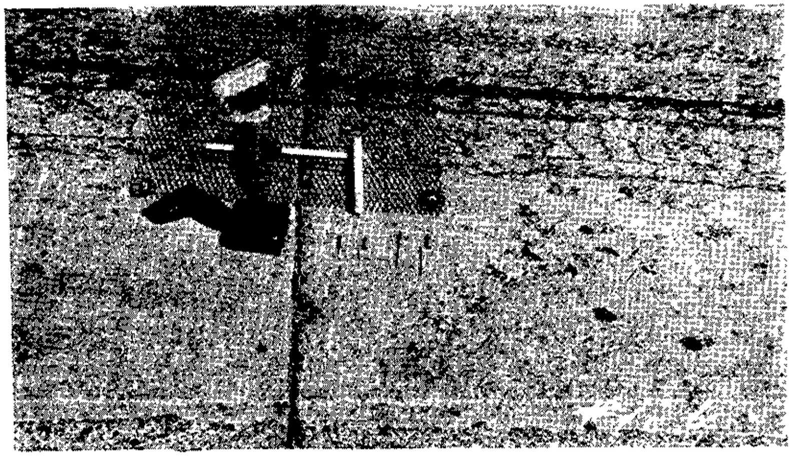


FIG. 7
Stud driver used in fastening sheets to P.C.C. pavement.

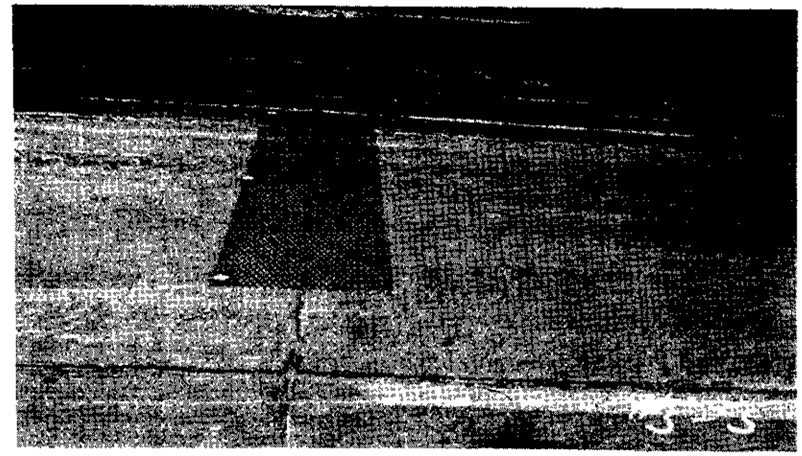


FIG. 8
2 ft. wide sheet fastened along leading edge. Paver approaches from left.

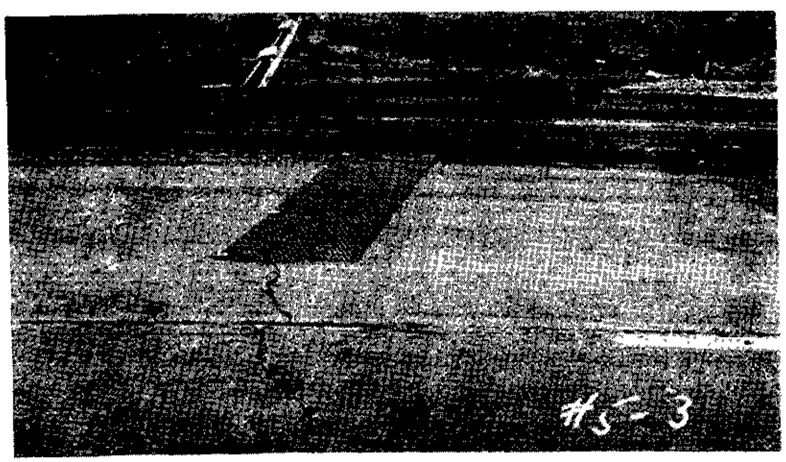


FIG. 9
2 ft. wide sheet placed over random crack.

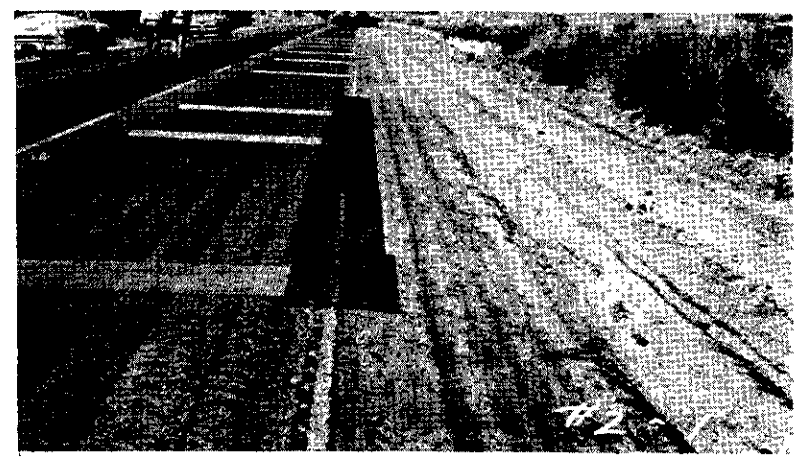


FIG. 10
Typical expanded metal test section just prior to paving. Short section of longitudinal joint covered.

District X-Sol-7-G
Bituminous Road Mesh

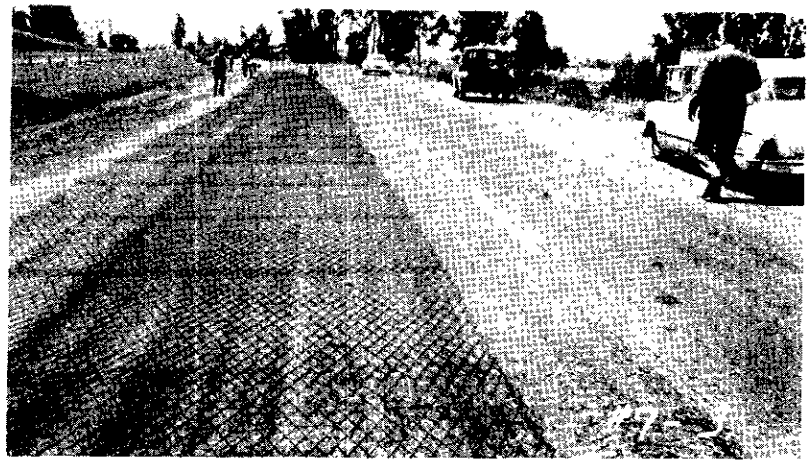


FIG. 11
Test Section with 3- by 8-in. diamond mesh.
New centerline will be at inner edge of wire.
On left, sheets cover 4 ft. of cement treated base.

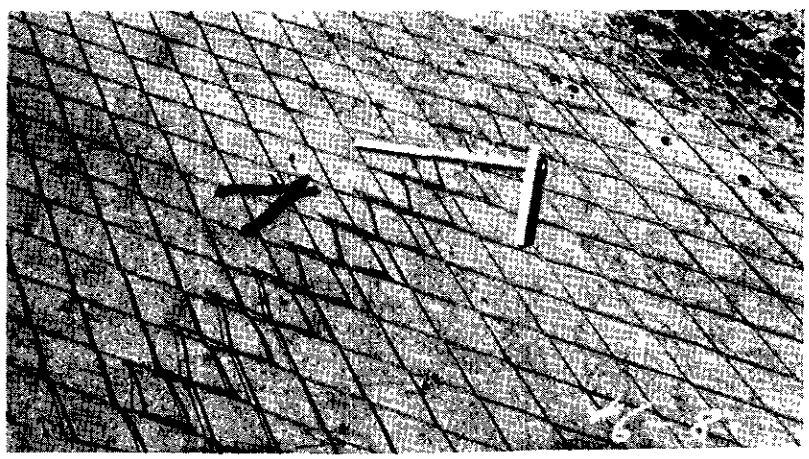


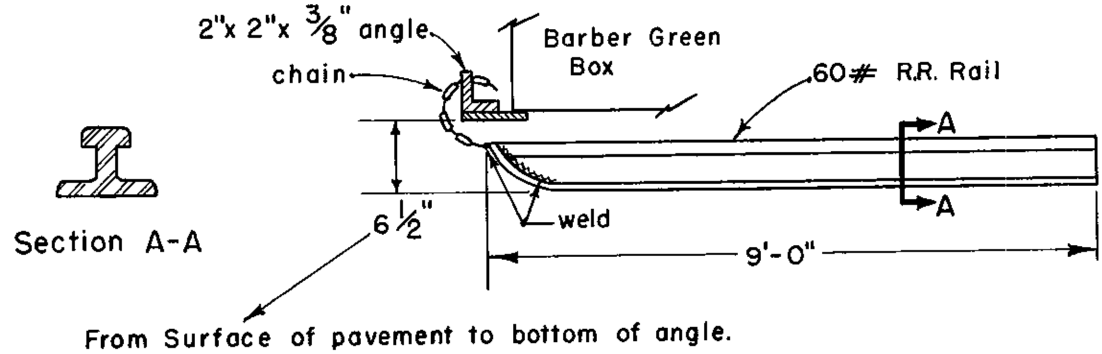
FIG. 12
Lapping of sheets. Wires are tied with
hog rings about every fifth diamond

FIG. 13
Sleds used to hold down
road mesh and welded wire fabric.

Fig. 14

OUTER SLEDS

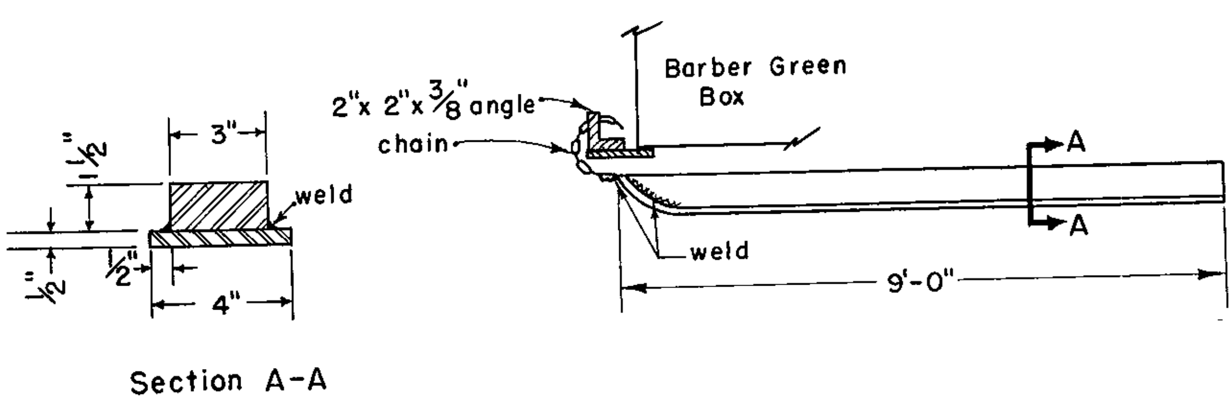
Two used on outside of tracks



1. Total weight of outer R.R. sleds 180 # per sled.
2. Total weight of inside sleds = 198 # per sled.

INSIDE SLEDS

Three used between the tracks



STATE OF CALIFORNIA DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPARTMENT

Details of Sleds

WIRE MESH TEST SECTIONS

X - Sol - 7 - G June 1954

District –X-Sol-7-G
Bituminous Road Mesh

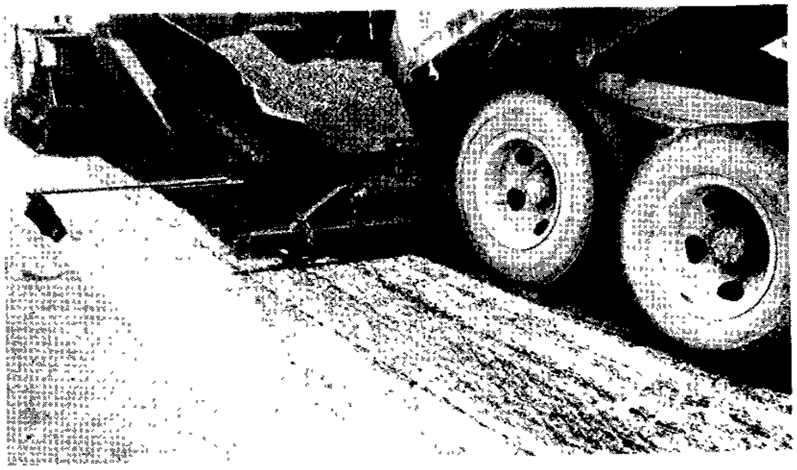


FIG. 15
Close-up of paving operations.
Note sled attachment on left.

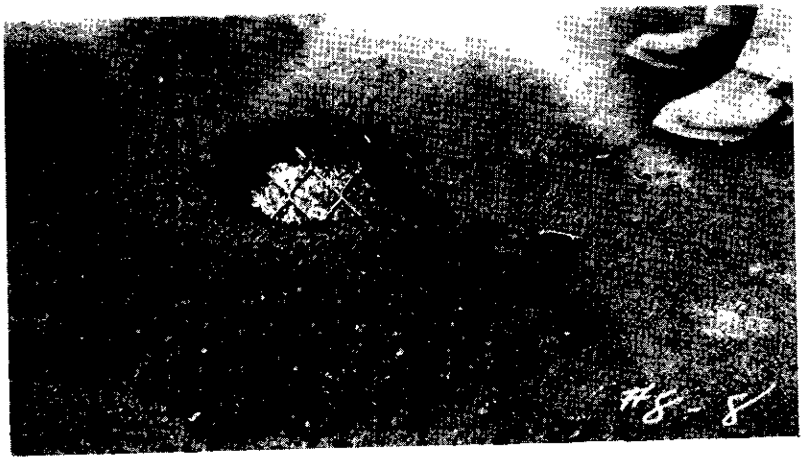


FIG. 16
Position of mesh after
placing leveling course.

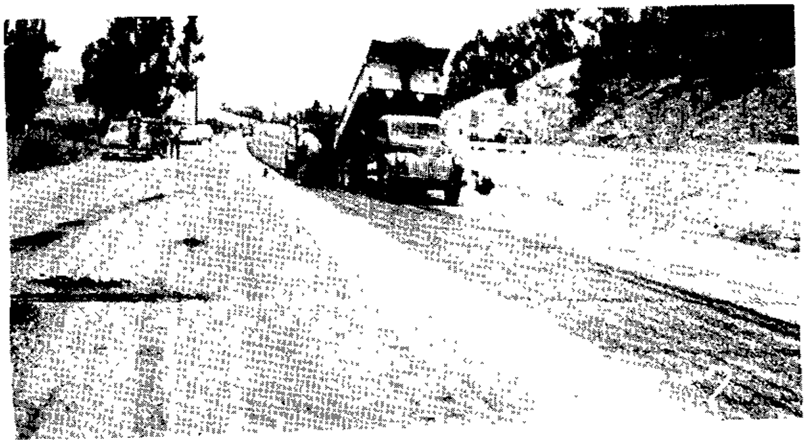


FIG. 17
Paving over 3- by 8-in. mesh.

District X-Sol-7-G
Welded Wire Fabric

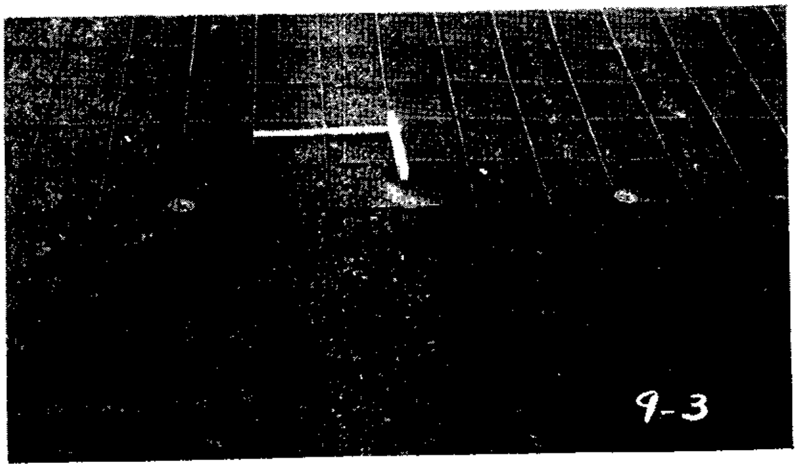


FIG. 18
Fastening leading edge of first sheet.

FIG. 19
Laying 3-by 6-in. wire fabric.
Left edge covers 4 ft. of cement treated base.

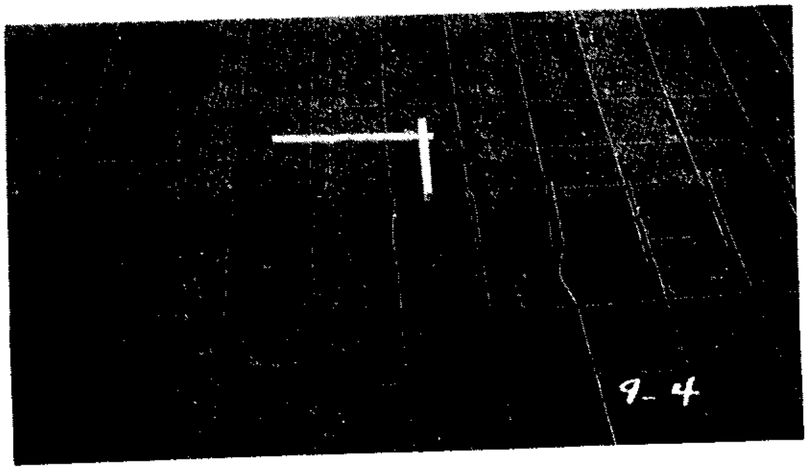


FIG. 20
Lap of sheets. Longitudinal wires tied with hog rings every fifth to seventh square.

District X-Sol-7-G
Welded Wire Fabric

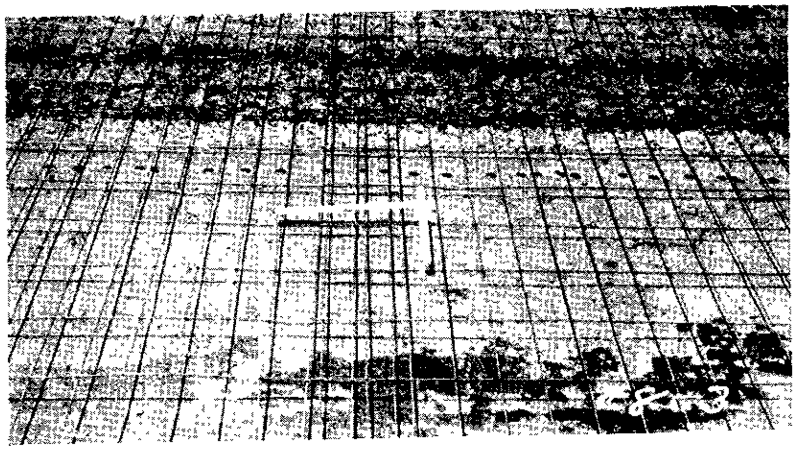


FIG. 21
Lap in 3- by 6-in. mesh.

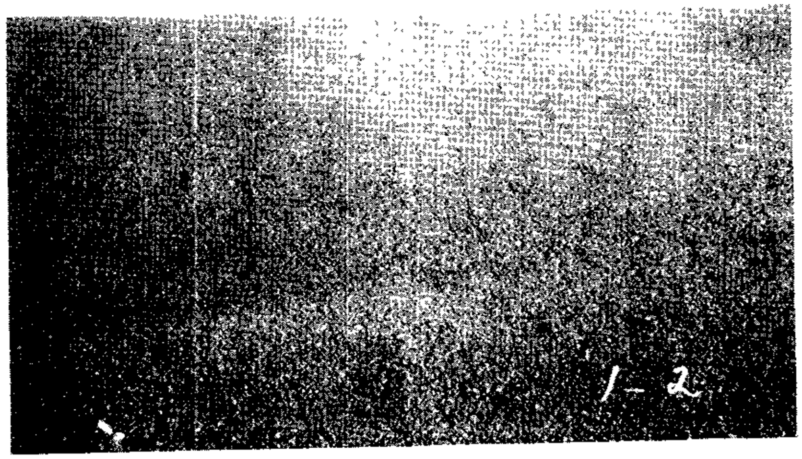
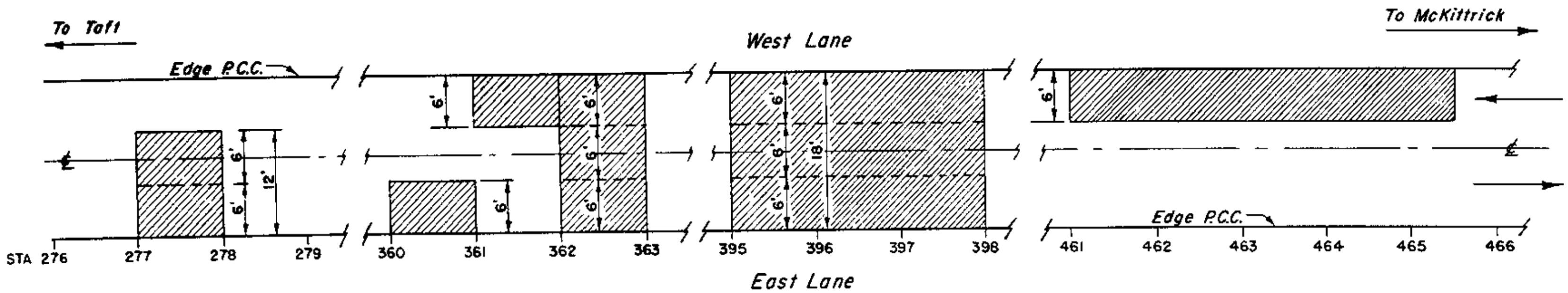


FIG. 22
Typical transverse cracking of leveling course following first roller pass. Cracks were closed by traffic within 24 hours.

FIG. 23
Position of fabric after completion of leveling course.



Note: All Test Sections were laid with 6"x 6" - 10/10 Welded Wire Fabric delivered to the job site in rolls 6' wide by 200' long.

WIRE MESH TEST SECTIONS

VI - KERN - 138 - A, B

FIG. 24

District VI-Kern-138-A,B
Welded Wire Fabric

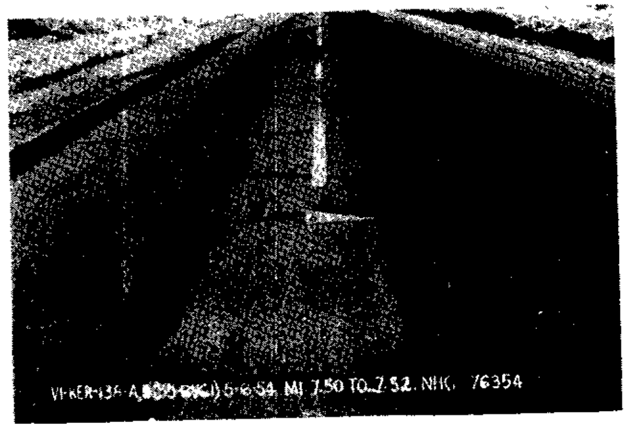


FIG. 25
General view of pavement prior to blanketing.

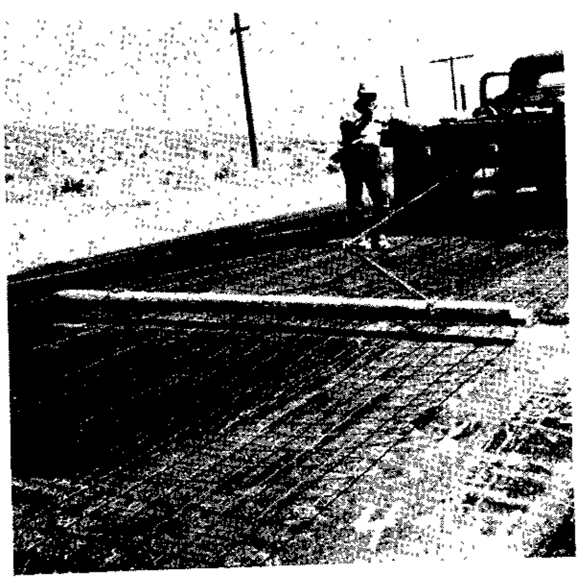


FIG. 26
Method of applying tension to wire.

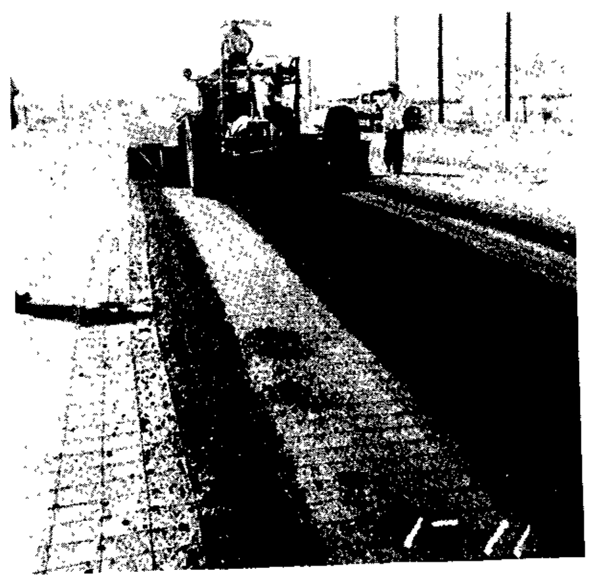
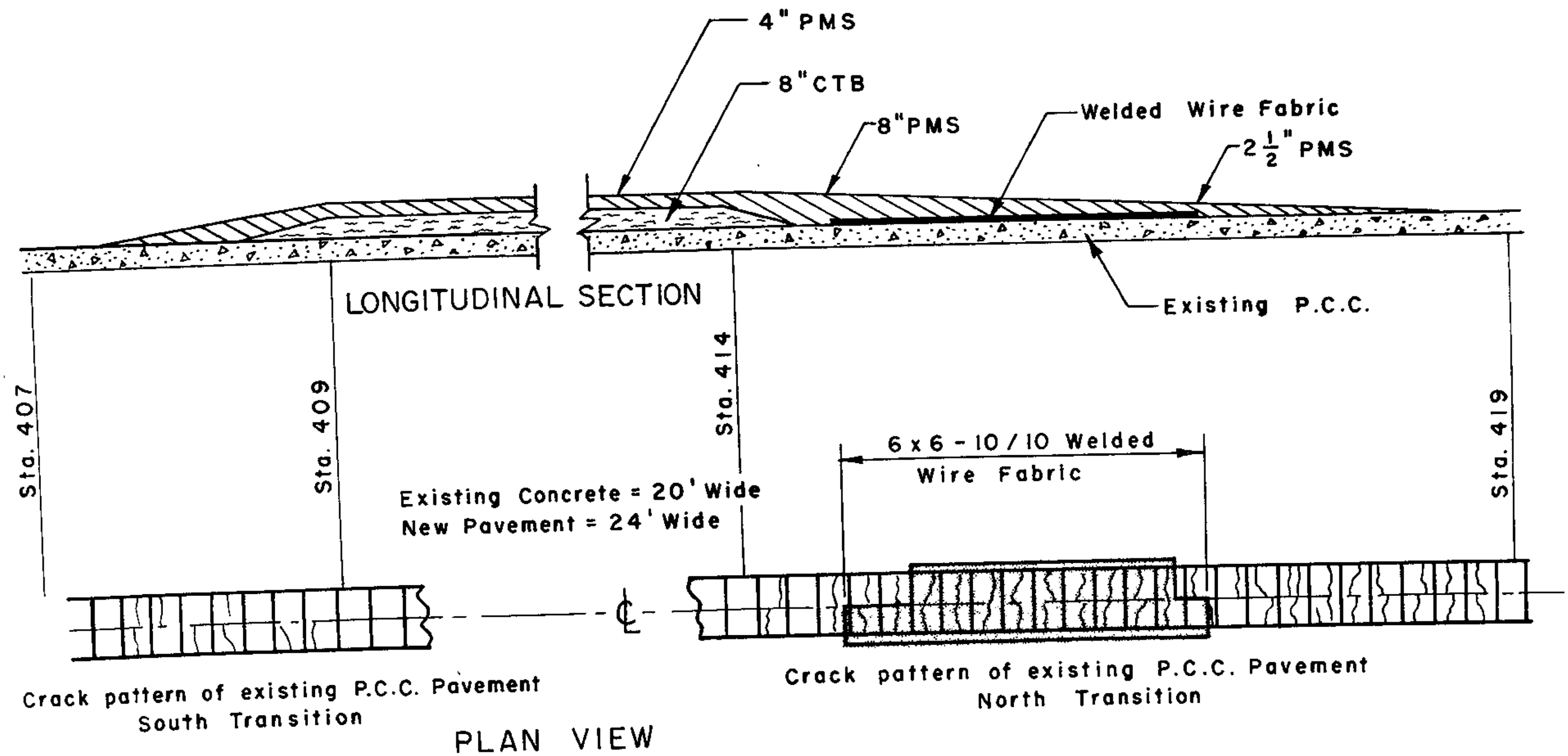


FIG. 27
Spreading leveling course.



WELDED WIRE FABRIC TEST SECTION

V-SB-2-D,C

FIGURE NO. 28

TABLE 1

Cost Analysis for Wire Installations on Contract 55-10TC2, X-Sol-7-G

Type of Metal	Expanded Metal		Expanded Metal		Expanded Metal		Expanded Metal		Bituminous Road Mesh		Welded Wire Fabric	
Size	1/2"x#20	1/2"x#20	3/4"x#16	3/4"x#16	3/4"x#13	3/4"x#13	1-1/2"x#16	1-1/2"x#16	3-12-30	6-36-20*	3"x6"	6"x6"
Width or Width and Length	2'	4'	2'	4'	2'	4'	2'	4'	11'-6"x8'	11'-6"x8'	11'-6"x8'	11'-6"x8'
Materials Costs												
Metal Sheets $	128	256	143	286	203	406	115	230	860	489	665	478
Delivery and Unloading $	26	26	26	26	26	26	26	26	52	52	52	52
Studs $	46	46	46	46	46	46	46	46	3	3	3	3
Cartridges $	24	24	24	24	24	24	24	24	2	2	2	2
Discs $	6	6	6	6	6	6	6	6	(Included in cost of cartridges)			
Tie Supplies (Hog rings) $	-	-	-	-	-	-	-	-	3	3	3	3
Sled Installation on Paver $	-	-	-	-	-	-	-	-	40	40	40	40
Total Material Costs $	230	358	345	388	305	508	217	332	960	589	765	578
Labor Costs	24	24	24	24	24	24	24	24	79	79	79	79
Grand Total $	254	382	269	412	329	532	241	356	1039	668	844	657
Total Sq. Yds of Pvt. in Section	444	444	444	444	444	444	444	444	1701	1701	1701	1701
Cost/Sq.Yd of Pvt. Surface $	0.57	0.86	0.61	0.93	0.74	1.20	0.54	0.80	0.61	0.39	0.49	0.38

*Only 20 sheets of 6-36-20 Bituminous Road Mesh were laid. The noted cost figures are theoretical values for laying an area equivalent to the 3-12-30 Bituminous Road Mesh and welded wire fabric sections.

TABLE 2

Cost Per Sq. Yd. of Various Types of Wire Mesh

Type	Designation	Width of Expanded Metal	Case I Joints only*				Case II Joints plus one Transverse Crack Per Slab*			
			Cost prorated per 180 sq.ft. of pavement Assumed that concrete is 12' wide with 15' joint spacing				Cost prorated per 180 sq. ft. of pavement Assumed that concrete is 12' wide with 15' joints and 1 transverse crack per slab			
			Metal Cost	Installation Cost (4 Studs per 12' Sheet	Cost Per Slab 15' long x 12' wide	Cost/sq.yd. of mesh	Metal Cost	Installation Cost (4 Studs Per 12' Sheet	Cost Per Slab 15' long x 12' wide	Total Cost/ sq. yd. of mesh
Expanded Metal	1/2"x#20	2'	3.66	1.52	5.18	0.26	7.32	3.04	10.36	0.52
		4'	7.32	1.52	8.84	0.44	14.64	3.04	17.68	0.88
Expanded Metal	3/4"x#16	2'	4.09	1.52	5.61	0.28	8.18	3.04	11.22	0.56
		4'	8.18	1.52	9.70	0.49	16.36	3.04	19.40	0.98
Expanded Metal	3/4"x#13	2'	5.79	1.52	7.31	0.36	11.58	3.04	14.62	0.72
		4'	11.58	1.52	13.10	0.65	23.16	3.04	26.20	1.30
Expanded Metal	1-1/2"x#16	2'	3.29	1.52	4.81	0.24	6.58	3.04	9.62	0.48
		4'	6.58	1.52	8.10	0.40	13.16	3.04	16.20	0.80
Bituminous Road Mesh	3-12-30 (3"x8" diamonds)		10.23	1.97	12.20	0.61	10.23	1.97	12.20	0.61
Bituminous Road Mesh	6-36-20 (6"x12" diamonds)		5.77	1.97	7.74	0.39	5.77	1.97	7.74	0.39
Welded Wire Fabric	3x6-10/10		7.91	1.97	9.88	0.49	7.91	1.97	9.88	0.49
Welded Wire Fabric	6x6-10/10		5.69	1.97	7.66	0.38	5.69	1.97	7.66	0.38

*Coverage applies to expanded metal only

Table 3

Cost Per Mile of Various Types of Wire Mesh
for Specific Condition of Existing Concrete Pavement

Type	Designation	Width of Expanded Metal	Original Concrete Condition (12' Lane with 15' Joint Spacing)	
			Jts. Only No Cracks Cost/Mile for 24' Pvt. Width.	Jts. + 1 Transverse Crack Per Slab. Cost/Mile for 24' Pvt. Width
Expanded Metal	1/2" x #20	2'	$ 3,660	$ 7,320
		4'	6,196	12,392
Expanded Metal	3/4" x #16	2'	3,942	7,884
		4'	6,900	13,800
Expanded Metal	3/4" x #13	2'	5,068	10,136
		4'	9,152	18,304
Expanded Metal	1-1/2" x #16	2'	3,380	6,760
		4'	5,632	11,264
Bituminous Road Mesh	3-12-30 (3"x8" Diamonds)	-	8,588	8,588
Bituminous Road Mesh	6-36-20 (6"x12" Diamonds)	-	5,492	5,492
Welded Wire Fabric	3"x6"-10/10	-	6,900	6,900
Welded Wire Fabric	6"x6"-10/10	-	5,350	5,350

Cost/Mile of 1" of added thickness of P.M.S. for 24' Pavement = $ 3,878

Cost/Mile of 1½" of added thickness of P.M.S. for 24' Pavement = 5,817

Cost/Mile of 2" of added thickness of P.M.S. for 24' Pavement = 7,756

(Based on average cost price of $5.10 per ton in place)