MEMO TO: D. V. Terrell  
Director of Research

Attached is a report on "Blown Mulch for Roadside Erosion Control" prepared by Jason C. Taylor and dealing with work of this type done on Project AF 62 (3), a reconstruction of part of U.S. 60 between Morganfield and Henderson. Observations and particular records included in the report were made at the request of the Division of Construction shortly after the erosion-control portion of the work was started in May.

The report shows that with some exceptions results obtained by use of the Finn machine were satisfactory, and undoubtedly this sort of mechanical method for applying mulch has distinct advantages over more-or-less hand methods of application under some circumstances. Obviously, it does not solve all the problems that are troublesome in seeding and mulching roadsides, and for the present at least a certain amount of hand work and special attention must supplement the use of the machine.

Of the various combinations of emulsified asphalt (RS-1) and straw which were tried, 150 gallons of emulsion and two tons of straw per acre produced the best results as determined by the stand of grass ultimately achieved.

Although initial observations indicated that ag lime, seed, and fertilizer could be mixed and blown satisfactorily (see Fig. 20), later inspections led to the conclusion that this attempt failed. At the time of application it was noted that the mixture of materials formed a coherent mass that coated the surface of the ground without actually penetrating the soil. Blown mulch which followed did adhere to this coating, but much of the seed failed to germinate. At the time of the
most recent inspection (October 25), erosion had removed practically all the mulch and the other materials too, leaving in this particular area barren slopes subject to further erosion.

On the whole the investigation has shown that blowing of mulches has merit, mainly from the standpoint of simplifying the handling and expediting the application of mulching materials in quantity.

Respectfully submitted,

L. E. Gregg
Assistant Director of Research

LEG:ddc
cc: Members of Research Committee
    Mack Galbreath (3)
BLOWN MULCH FOR ROADSIDE EROSION CONTROL

on

U. S. 60, Henderson - Morganfield Road
Project No. AF 62 (3)

by

Jason C. Taylor
Highway Engineer

Highway Materials Research Laboratory
Lexington, Kentucky

October, 1954
I

INTRODUCTION

In May 1954, the Division of Construction brought to the attention of the Research Division the fact that an effort was being made (for the first time in Kentucky) to revise the conventional manner of applying straw mulch to a seeded right-of-way. This innovation was to be achieved with the use of a recently-invented machine known as the "Finn Mulch Spreader", which is capable of mixing a straw mulch with some adhesive substance and then blowing the mixture onto the seeded area. The intent was to achieve a reasonably homogeneous mat-like structure composed of pieces of straw attached to each other by the adhesive material.

Project No. AF 62 (3), on the Henderson-Morganfield road, in Union County (see Fig. 1) was chosen as the site for the operations. Test sectors were designated by the Division of Construction to determine the overall practicability of the method described above. With special reference to growth of vegetation and prevention of erosion, attention was directed toward the effect of the following:

1. The quantity of adhesive material applied,
2. The quantity of straw applied, and
3. The pre-mixing of limestone, fertilizer, and seed, in proper proportions, and applying the mixture with the mulch spreader.

The purpose here is to give an account of the experimental aspects of this project, and to discuss their significance in relation to
extended use of the techniques involved. For the most part, the text of this report is based on a considerable number of visual observations which are illustrated by photographs. Descriptive data pertaining to all test sectors is summarized in Table 1.
Fig. 1 - Project Location: Morganfield-Henderson Road.
<table>
<thead>
<tr>
<th>TEST SECTOR NUMBER</th>
<th>Location and Station No.</th>
<th>RS-1 Per Acre (gal)</th>
<th>Straw Per Acre (tons)</th>
<th>Fertilizer Per 1000 Sq. Yds. (lb)</th>
<th>Limestone Per 1000 Sq. Yds. (lb)</th>
<th>Seed Mix Per 1000 Sq. Ft. (lb)</th>
<th>Date Seeded</th>
<th>Date Mulched</th>
<th>Germination Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>North Side, 8440+50 to 8470+48</td>
<td>70</td>
<td>2</td>
<td>30</td>
<td>100</td>
<td>4</td>
<td>5-26-54</td>
<td>5-26-54</td>
<td>5</td>
</tr>
<tr>
<td>(84, 313)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>South Side 8440+25 to 8471+00</td>
<td>140</td>
<td>2</td>
<td>30</td>
<td>100</td>
<td>4</td>
<td>5-25-54</td>
<td>5-25-54</td>
<td>4</td>
</tr>
<tr>
<td>(90, 423)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>North Side 8471+00 to 8494+00</td>
<td>150</td>
<td>2</td>
<td>30</td>
<td>100</td>
<td>4</td>
<td>5-27-54</td>
<td>5-27-54</td>
<td>4</td>
</tr>
<tr>
<td>(84, 313)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>South Side 8471+00 to 8494+50</td>
<td>200</td>
<td>2</td>
<td>30</td>
<td>100</td>
<td>4</td>
<td>5-27-54</td>
<td>6-2-54</td>
<td>6</td>
</tr>
<tr>
<td>(87, 130)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>South Side 8495+76 to (Asphalt 8523+00 T-4)</td>
<td>180</td>
<td>3</td>
<td>30</td>
<td>100</td>
<td>4</td>
<td>6-7-54</td>
<td>6-8-54</td>
<td>10</td>
</tr>
<tr>
<td>(98, 436)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The total area in square feet
FIELD OBSERVATIONS
Fig. 2 - View of the right-of-way after final dressing. Note that wide ditch lines, easy slopes and back slopes are prominent.

A standard-type fertilizer spreader was used to place the agricultural ground limestone and a commercial "6-8-6" fertilizer at the rates expressed in Table 1.

After the final dressing had been completed, the soil was disced in the usual manner. Ground limestone, fertilizer, and seed mixture were (in that order) applied to the area; each of these courses was followed by further discing. When all three applications had been made, the sector thus treated was harrowed to the proper texture. The only departure from this procedure occurred when these three materials (limestone, fertilizer, and seed mixture) were premixed and blown onto a relatively small test sector with the Finn Mulch Spreader.
Fig. 3 - Finn Mulch Spreader and Auxiliary Unit. A truck equipped with a 500-gallon tank (1) carries the straw supply and tows the mulching machine. Flexible lines (2) - on the ground in this photograph - function as asphalt feed and return. The latter is used when the spray is not in operation and the relief valve is open. Essential parts include a feed chute (3), a beater and feeding mechanism (4), a positive displacement asphalt pump (5) having a capacity of 8.5 gpm., a 24-inch centrifugal fan (6) for blowing straw mulch, soil, fertilizer, or seed mixtures through the 8-inch-diameter discharge spout (7), and an asphalt spray assembly (8). The spreader is powered by a 30.2 hp gasoline engine, which the manufacturers claim is capable of delivering from 40 to 200 gallons of liquid per ton of straw. On this project mulch was placed at the rate of approximately 1 ton per hour. The operating crew consisted of a truck driver, two straw feeders, a spreader operator, and flagmen.
Fig. 4 - Near view of the Finn Mulch Spreader. Straw is conveyed down the feed chute (3) and is broken manually before entering the housing, which contains a beater-type feeding apparatus (4). This mechanism consists of three rotating, prong-type beaters whose function is to break, by separating and straightening, matted straw and to feed it into the centrifugal fan (6).

If the straw is dry, it is readily mulched by the machine, but if it is wet, separation and dispersion are more difficult. If clogging occurs, removal of the triangular shield provides access to the feeding mechanism. Cleaning is rarely necessary when grain straw is used.

The 8-inch-diameter discharge spout (7) is connected to the blower (6) by a flexible ell, allowing variations of as much as 40 degrees upward from the horizontal. The spout assembly is ball-bearing mounted and may be rotated through an arc of 210 degrees. The counter-balanced arm (9) of the spout, as well as a spring-loaded asphalt delivery valve, are controlled by manipulation of a cord and lever arrangement (10). The rectangular box-like appurtenance (11) on top of the beater housing is used for mounting a device which feeds soil, fertilizer, or seed mixtures into the fan. This method of seeding and fertilizing was used on one test section during a latter part of the project.
Fig. 5 - Near view of the discharge spout and asphalt feed lines and nozzles. Dry straw is being blown through the zone of mist created by the fan-shaped sprays. Asphalt is pumped through the small line shown along the top of the boom. Nozzles are connected to the feed line by a tubular bridle mounted around the orifice of the discharge spout and are directed so that the material from all three will converge near the center of the straw flow, thus attaining maximum possible coverage. The third nozzle, located on the opposite side of the spout, is not shown.

A straw fragment is not "coated" in the sense that it is completely covered with asphalt, but rather that it is spattered with many tiny droplets of asphalt distributed over its outer surface. Only enough asphalt to cause individual particles to adhere to each other is desired. Variation in the application rate of asphalt is achieved with interchangeable nozzles having different aperture sizes.

Some straw may be seen falling from the principal flow stream. These particles are more fully coated with emulsion and are therefore heavier than the pieces in the main flow line. Since these bits of straw reach the roadside first, there results a thin layer of well-coated straw in contact with the ground. A more uniform coverage is achieved if the boom is oscillated horizontally through a small arc during operation, much the same as one might use a garden hose.
Fig. 6 - Excellent dispersion of straw is illustrated by this photograph. Note the downward bending caused by a strong cross wind. However, high winds may sometimes make direction of the flow stream difficult, and proper coverage is impossible. Moderate winds can be tolerated if the operator is sufficiently skilled and capable of compensating for this influence. Since the discharge spout must be rotated for uniform coverage, wind correction is constantly applied. Lack of proper correction and control can result in an appreciable loss of mulch material.

The workman who was operating the machine at the time this picture was taken had had considerable experience at directing the flow stream. However, a new operator was broken in while the work was in progress, and by his second day had managed to cope with moderately strong winds.
Fig. 7 - The non-uniform dispersion of straw shown here results in very poor coverage. This condition may be caused by: (1) the use of wet straw, (2) incomplete breakage of bales prior to feeding into the beater, or (3) the use of excessive amounts of asphalt emulsion. The resultant layer on the roadside lacks homogeneity and the greater part of the straw is (if the first two causes apply) inadequately coated. The most damaging effects are manifested in too-heavily matted spots beneath which the growth of vegetation is hindered, or in thinly-layered areas that are more susceptible to agents of erosion, such as strong winds and heavy rains.

In this illustration the flow stream is directed into the wind and deposited straw is more concentrated. If proper corrections are made, this does not represent an especially disastrous situation. A head wind may normally be expected at some point within the operating arc and its principal effect is to shorten the radius of mulch application.
During the project a considerable quantity of mulch was blown onto the pavement, and often extended as far as 6 feet from the edge. No significant loss of material was incurred, but since the pavement edge in these instances was obscured, a slight traffic hazard was encountered. However, automobiles rapidly whipped most of the straw from the road. More serious damage was caused by passing vehicles which set up air currents that displaced mulch on the shoulders near the pavement edge before the asphalt could harden enough to hold the straw mat intact.

During the initial phases of construction, an attempt was made to blow the mulch onto the edges with the discharge spout at a low angle - parallel to and approximately 6 feet above the shoulder. With the spout in this position, the velocity of the straw was too great and "balling" of the material resulted. However, the balled straw was easily blown off the pavement by passing vehicles.

The procedure was later altered so that center sections of the roadside were treated before the edges. The discharge spout was then maintained at a relatively high angle and straw floated into the correct position on the edge. This latter method held loss of straw and balling to a minimum.
Fig. 9 - This figure shows the "blow-back" condition resulting from currents set up by passing vehicles. The photograph was taken after the mulch had been in place approximately 24 hours. Displacement varied from 1 to 4 feet from the pavement edge, and exposed soil suffered from wind erosion, forming a hard crust quite rapidly. In the position shown, displaced straw formed a firm mat which was resistant to further movement.

It was therefore necessary to devise a means of keeping traffic away from the edges for a short period (approximately 3 hours) to permit partial curing. For this purpose, automobile tires were placed at intervals along the pavement edge. The initial appearance of the mulch material was similar to that shown in Fig. 8. However, straw was blown away from the tires by the first few vehicles that passed. This procedure temporarily reduced the width of the road and created mild traffic difficulties during the three-hour period that the tires remained on the pavement. After two hours exposure the pavement was almost clear of mulch, but the edge remained well covered.

The "tire method" was effective in many cases, but traffic often continued to blow the mulch back onto the shoulder for short distances in some areas.
Fig. 10 - Patching along the pavement edge was necessary for almost the entire length of the right-of-way. Several methods were tried, but only one proved satisfactory. The use of automobile tires (see Fig. 9 caption) was discontinued in favor of the procedure illustrated here. In a separate operation a crew remulched bare areas by hand with uncoated straw, and extended a crisscrossed-string-tiedown system from the pavement edge onto the shoulder for approximately 3 feet. Asphalt emulsion was then sprayed in a checker pattern over the area as shown here. This method was far superior to all others attempted and prevented removal of mulch from the pavement edge.

On this project the tying down was a separate procedure and required additional material. Although partial sweeping of the pavement would be necessary, it appears that it may be quite practical to tie the straw (at least along the pavement edges) in this manner before it is displaced by traffic.
Fig. 11 - The edge of this sector was treated by the string-tie-down method illustrated in Fig. 10. The mulch had been in place for one month with no significant displacement of material. Note that growth of vegetation is uniform and has not thinned at the edge.

Fig. 12 - Four rates of mulch application were employed (See Table 1). The rate used here was 2 tons of straw and 70 gallons of asphalt emulsion per acre. This photograph was taken approximately 48 hours after mulching, and serious displacement is obvious. This backslope is relatively steep and slippage (aided by wind) was prominent. At this application rate, adhesion was expected to be poor whenever such slopes were encountered. Regions that were quite level showed little early damage.

This sector was repaired by a second application of mulch at the rate of 2 tons of straw and 150 gallons of asphalt emulsion per acre, and good coverage was thus obtained.
Fig. 13 - Location shown in Fig. 12 one month after patching of bare areas was completed. With the exception of small isolated spots, coverage is still rather complete.

After two months exposure some bare spots were visible, but they had enlarged very little during the additional period. Vegetation had developed rapidly on the berm and in the ditch, but only slightly on the steep backslope. This problem was encountered many times during the course of the project.
Fig. 14 - A sector treated at the rate of 2 tons of straw and 150 gallons of asphalt emulsion per acre (photographed 11 weeks after the treatment). Patching was limited to small sections adjacent to the pavement edge. Light areas shown in this illustration are exposed straw, not bare soil.

Less vegetation is visible here than in areas previously shown which had lighter asphalt treatments. This may be ascribed to rainfall conditions rather than to any effect of the asphalt. At this location the heavier asphalt treatment gave better results than lighter treatments elsewhere, in that the mulch formed a better mat at the pavement edge and on slopes.
Fig. 15 - The area shown here gives a comparison of two mulch treatments having equal quantities of straw, but different amounts of asphalt emulsion. The section to the left of the pavement was treated with 150 gallons per acre, and the one to the right, 70 gallons per acre. Both received the same amount of patching and their initial appearance was quite similar except for color. Neither edge was tied down, but it is evident that adherence was better along the area which had the heavier treatment. Note also the backslopes near the center of the picture; although they have equal grades, the heavy treatment has remained intact, while the light treatment has not. It may also be of interest to note that vegetation growth is more dense on the side which has the greater quantity of asphalt.
Fig. 16 - Near view of a typical mulch pattern achieved with a straw application rate of 2 tons per acre. This particular location had an asphalt application rate of 150 gallons per acre. An average mat giving complete coverage was approximately 1 inch thick when placed and about 0.5 inch thick after settlement. Weathering tends to flatten the mulch material until it appears to have been rolled. Lower portions of the mat become incorporated into the soil, thus preventing wind and water erosion of both soil and straw. As a rule, the mat is sufficiently open-textured to permit the soil to "breathe" and hence does not impede growth of vegetation. At the same time the mat is dense enough to prevent excessive evaporation of soil moisture which is necessary for seed germination.
Fig. 17 - General view of a section treated with 2 tons of straw and 200 gallons of asphalt emulsion per acre. It was necessary to apply mulch to the bridge deck separately, so the test sector actually begins about 6 feet beyond the handrail. Mulch had been applied four hours before this photograph was taken, and the usual method (with a different rate of application) was employed in placing the material. Preparation work (discing, seeding, etc.) was finished five days before the straw mulch was put into place, and intermittent rainfall and evaporation during that period brought about the formation of a hard crust on the soil surface over the entire area. Progress was further interrupted by high winds, which caused additional drying and hardening of the treated area, and as a result, straw particles could not bind into the soil.

After seven weeks exposure, the area in Fig. 17 showed little displacement except near the pavement edge. Badly-damaged portions on the bridge deck appeared where no asphalt had been applied.

After eleven weeks exposure, the same bare sections (previously described to have been sparsely covered) were visible. Very little enlargement of these areas occurred.

It was observed that seed had germinated beneath the soil crust on some parts of this 200-gallons-per-acre section, but shoots could not penetrate the hard surface of the soil.
Fig. 18 - One section was treated with 3 tons of straw and 180 gallons asphalt emulsion per acre. Coverage on this sector was excellent with no sparse areas in the mat; mulch adhered well to very steep slopes. The bare spot at the right was not the result of displacement by wind or rainfall. The region shown in this photograph had been exposed for 10 weeks. Mulch was tied down along the pavement edge, and no damage (other than that caused by vehicles leaving the pavement) was observed. Growth of vegetation is noticeably deterred, but the density of this mat is greater than on other sections — apparently restricting rather than encouraging growth.

The section opposite from the one just described had the same treatment, but vegetation on this side was more dense, perhaps due to drainage from the super-elevated curve.
Fig. 19 - Discing operations were more difficult at bridge abutments, culverts, or at any place on the right-of-way where the equipment had to make a turn to change its direction. Turning of the discer produced furrows which were perpendicular rather than parallel to the center line - a condition which encouraged channelized flow of rain water and subsequent erosion. At such locations erosion apparently can take place even though the soil may be covered with mulch. Consequently, sections such as these should be hand-raked.

At this location (adjacent to the abutment of the bridge shown in Fig. 17) preparation and seeding were completed four days prior to mulch application, and wetting and drying of the soil caused the formation of a hard crust which seriously impaired the adherence of mulch material.

After seven weeks exposure, little mulch had adhered to this slope and erosion continued to progress. This area received only a few light showers during the period after mulch application.
Fig. 20 - A different method of applying seed and fertilizer was used on one sector (in the village of Waverly). Surfaces to be seeded were prepared by discing in the usual manner. Seed and fertilizer were mixed in the proper proportions and blown into place with the Finn Mulch Spreader. A hopper attachment was used to feed the mixture into the fan (See Fig. 4). The mixture was wetted by being blown through a water mist provided by the spray system used in applying asphalt emulsion. This wetting procedure was initiated in order to offset the effect of wind while the mixture was being dispersed onto the roadside.

The sector shown had been seeded and mulched for about four weeks. Mulch was applied at the rate of 2 tons of straw and 150 gallons of asphalt emulsion per acre. Damage visible here is believed to have not been caused by wind or rainfall, but by chickens from a nearby farm.

In general, the mulch was in good condition, but seed germination was slower than in sections seeded by the other method.
Fig. 21 - Area shown in Fig. 20 after an additional four weeks exposure (a total of eight weeks). The extent of seed germination and plant growth was approximately the same as that observed in other sections having the same age, but it appears to be "spotty", indicating possible erratic distribution of seed. Because of this apparent non-uniform dispersion of material, the method is of questionable merit.
III

SUMMARY OF OBSERVATIONS

This report has described a relatively new method of applying straw mulch to seeded roadsides. Many pertinent observations have been recorded, with regard particularly to the effectiveness and suitability of equipment and methods employed.

Since periodic inspections of this project have not yet been terminated, conclusions, as such, are not in order. However, certain relationships believed to be significant are discussed below:

(1) The Finn Mulch Spreader provides a simple and satisfactory means of distributing and placing asphalt-bound straw mulch. Straw is blown through an asphalt mist and the mixture deposited as a loose-textured but reasonably homogeneous mat. The quantity of straw and asphalt may each be regulated to produce a variety of types of application.

(2) Under moderate wind conditions, uniform dispersion of mulch may be obtained except when straw is wet or excess quantities of asphalt are employed. High winds can make the flow stream difficult, and sometimes impossible, to control.

(3) Good coverage of any large area to be treated may readily be obtained; however, it is usually difficult to maintain this coverage near the pavement edge. Gusts of wind created by passing vehicles tend to move the straw
to a distance extending as far as 3 feet back onto the shoulder. This condition can best be remedied by hand-patching with straw, accompanied by string tie-downs. Asphalt emulsion is then sprayed in a crisscrossed pattern onto the hand-worked area.

(4) If proper coverage of the area adjacent to the pavement edge is to be obtained, it is necessary to blow a considerable quantity of mulch onto the pavement itself. A slight traffic problem is sometimes incurred by this procedure (a portion of the pavement being obscured), but the material shows little tendency to adhere and is soon blown aside by traffic. In some cases, automobile tires were used to protect the shoulder edge, but this method proved of little advantage and even created (by narrowing the normal width of the road) an additional hazard. The use of cone-type markers might be more desirable than tires, but it is doubtful that there is a need for any kind of marker unless the center line is obscured.

(5) Straw was applied at two rates: two tons per acre and three tons per acre. The quantity of asphalt emulsion was varied in sectors where straw was applied at two tons per acre while only one amount was used with the latter rate of straw application.
The lowest rate of asphalt emulsion application was 70 gallons per acre. This volume was judged to be too small to provide proper adhesion within the mulch. In this case the effects of wind and water were rather severe on all steep slopes and at the pavement edges. Backslopes usually required additional treatment with asphalt to insure coverage.

The second and most practicable asphalt emulsion application rate was found to be 150 gallons per acre. As a rule, mulch was well dispersed and good coverage was obtained. Adhesive action gave sufficient protection against wind and water, and coverage remained satisfactory except near the pavement edge. Retention on backslopes was excellent.

Asphalt emulsion was applied at the rate of 200 gallons per acre in only one sector. This greater amount caused balling of straw as it was blown from the spreader, and dispersion was less uniform. Another effect was that discrete straw fragments had apparently lost the ability to exert any adhesiveness both in the air and in the mat. While the overall structure of the mat was reasonably good, it showed a tendency to act as a continuous unit and roll up under strong winds, much the same as a large carpet. Adherence on slopes was no better than that obtained on sectors treated with 150 gallons per acre.

A fourth treatment consisting of three tons of straw and 180 gallons of asphalt emulsion per acre was applied to one
sector. Coverage and adherence was excellent, but no better than most areas treated with 150 gallons of emulsion and two tons of straw. The mat obtained with this treatment was quite dense and seemed to hinder the growth of vegetation.

(7) One sector was dressed and seeded several days prior to mulch application and received some rainfall during the period of exposure. As a result of wetting and drying, a hard crust was formed on the surface, thus preventing the mulch from properly "tying" into the soil. These undesirable events clearly emphasized the need for prompt coverage of seeded areas.

(8) In one sector, limestone, fertilizer, and seed were mixed in proper proportions and blown onto the roadside with the Finn Mulch Spreader. This method appeared to result in an unequal distribution of material and was therefore held to be inferior to the conventional procedure. However, it is a time-saving device which might be applicable if certain refinements could be made, e.g., an increase in the quantity of seed mixture might compensate for uneven dispersion.

This method seems to offer excellent possibilities where it is necessary to re-seed or re-fertilize a right-of-way. The work could be accomplished without damage to existing turf, and seeding during the late winter months would permit frost action to imbed the seed, thus providing favorable conditions for germination.