ust Control During Construction Operations

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Soil and weather conditions during construction of highways are often conducive to extensive dust formation. Dust may become a serious hazard to traffic and to residential areas if in the immediate vicinity of the job. It also presents a definite health hazard to working men.

The necessity of dust control has long been recognized. The most common medium for dust control has been, and in most instances continues to be, the use of water applied as often as necessary to "lay the dust."

To achieve a reduction in the cost of frequent water sprinkling, hygroscopic salts have been used in areas of relatively high humidity and diluted mixing-type asphaltic emulsion has been tried by a number of states. Recently a number of new products have made their appearance on the market.

On many of our California highway construction jobs the new project parallels the present travelway, or borders residential areas where the presence of dust in the air becomes a serious problem. In order to study the performance and possible economic advantages of various dust palliatives, a number of test sections were placed in the median strip on a recent highway project. The following products were used: water, diluted asphaltic mixing emulsion, a lignin product and a resinous petroleum product. Water proved to be the most expensive and for the most part the least effective method of combating the dust.

)URING CONSTRUCTION of our highways, the type of soil encountered combined h certain weather conditions are often times conducive to extensive dust formation)ecially in the more arid regions. Dust becomes a serious hazard to traffic, is rimental to orchards, increases the cost of equipment maintenance and constitutes uisance to residential areas if in the immediate vicinity of the job site. Dust also esents a definite health hazard to working men.

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In order to reduce the cost of frequent water sprinkling, certain hygroscopic salts e been used in areas of relatively high humidity and diluted mixing-type asphaltic ulsions have been tried by a number of states. Recently a number of new products e been developed and have been used on haul roads, certain open pit coal and ore ning operations, and in connection with the operation of air fields.

On a recent highway construction project the new construction paralleled the exist- roadway. The type of soil encountered in the new median strip and strong prevail- winds, created a serious dust hazard to the traveling public. To study the perform-e and possible economic advantages of various products, a number of test sections re placed in the median strip area.

DESCRIPTION OF THE TEST SITE

The project consisted of constructing 5.6 mi of new concrete pavement between 1.0 north of Greenfield and the Salinas River on US 101 in Highway District V. It was structed during 1957 under Contract 58-5TC4F. The route location is referred to V-Mon-2-D. The new alignment parallels the existing two-lane highway throughout

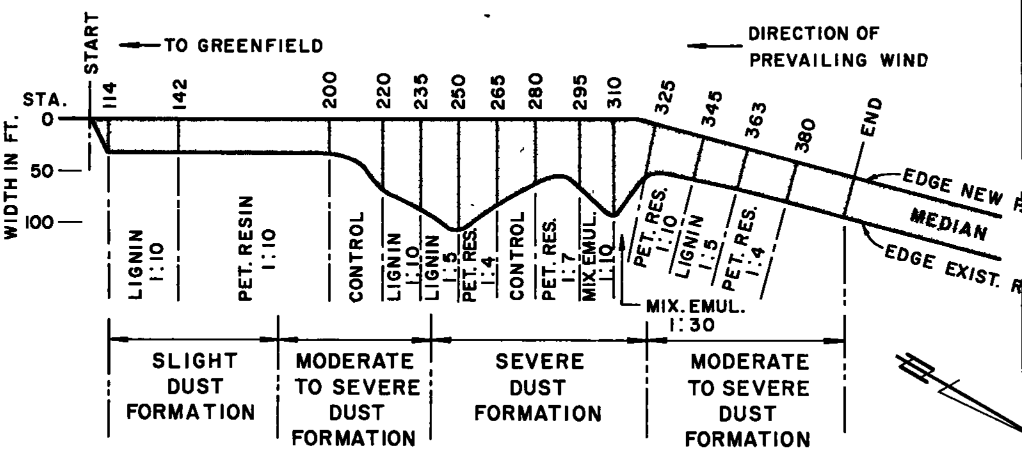


Figure 1. Dust control test sections—road V-Mon-2-D test sections laid on Aug. 12, and 14, 1957.

the entire 5.6 mi. The new roadbed is raised above the existing travelway and nece sitated extensive grading on the median strip. The new median varies from 35 to about 100 ft in width with 1:6 side slopes (Figs. 1 and 2).

Soil conditions on about 80 percent of the job made the area highly susceptible to vere dust formation, especially where the median was the widest. Unfortunately thi area has also a serious wind problem during the summer months. Winds of 25 to 3 mph occur almost daily in the Salinas Valley, and on the job site such winds began about 11 a.m. and subsided about 7 p.m. The wind direction was almost parallel to the major portion of the project. A serious dust hazard developed shortly after sta of construction requiring extensive and continuous dust abatement, which was done sprinkling with water up to the time of the laying of the test sections.

DESIGN

During discussions with the resident engineer the following information was obta relative to the dust problem on this contract. Dust formation was very severe betw stations 180± and 400±. From station 108 to 180±, the new construction is in an ar of rather granular rocky material, which only generated minor amounts of dust. It interesting to note that this area continues southward beyond Greenfield where a si lar job was built without any serious dust hazard. It might be significant that the fa ing region also terminates in this area, indicating a marked change in soil characte tics. The field observations are further substantiated by the results of sieve analys and sand equivalent tests on representative samples from the median strip (Table 1

TABLE 1

GRADING AND SAND EQUIVALENT VALUES FOR SOILS FOUND IN THE MEDIAN ON CONTRACT 58-5TC4F, ROAD V-MON-2-D

			Grading—Percent Passing													
Test No.	Sta. to Sta.	Dust Formation	2 in.	1½	1	¾	⅜	4	8	16	30	50	100	200	5µ	1µ
57-1870	110+00 to 180+00	Slight	100	97	92	87	79	74	69	60	47	24	12	7	4	3
57-1871	180+00 to 240+00	Moderate to severe	—	100	99	98	96	95	93	88	73	49	31	20	10	8
57-1872	240+00 to 310+00	Severe	—	—	—	—	—	100	99	99	96	91	80	63	25	16
57-1873	310+00 to 400±	Moderate to severe	—	—	—	—	100	99	98	97	93	78	62	57	27	17

The most severe dust formations occurred between stations 180± and 325±. It will noted from Figure 1 that the median strip is quite wide in this area and the prevail- winds, averaging 20-25 mph, blow almost parallel to the alignment. It appears t the slight difference in intensity of dust formation between stations 180 to 325 and to 400± is due to the change in alignment and the differences in median width. Af- consultation with the resident engineer, a series of test sections were laid out and necessary quantities of concentrates for the various types of proposed dust pallia- es were determined and ordered.

The final test section (Fig. 1) was based on the objective of comparing a number of wn commercially available products at dilutions recommended by the vendors. Mix- -type asphaltic emulsion, a petroleum resin product, and a lignin sulfonate were sen for the trial.

The properties of the standard mixing-type emulsions are well known and no further scription is required. The petroleum resin product is a concentrated emulsion com- sed of semi-liquid petroleum resins together with wetting agents and water. The concen- te may be further diluted with varying proportions of water. The wetting agents in-

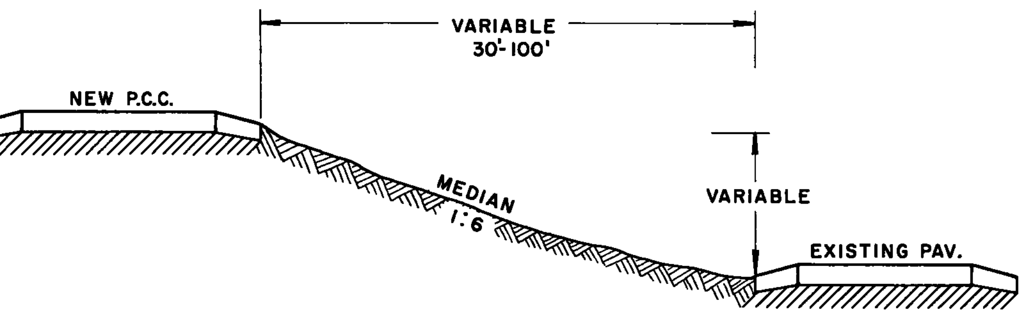


Figure 2. Cross-section—dust control test sections, road V-Mon-2-D.

ase the spreading power of the diluted emulsion and also increase the penetration the dust layer. The active cementing agent, for the dust forming particles, is the roleum resin fraction. Because this fraction is derived from petroleum, it is insol- e in water and is not leached out by rain. It is of a yellowish color and shortly after lication the treated surface appears almost the same color as the original ground. e lignin sulfonate is derived from waste products obtained in the manufacture of paper ducts. The material is a lignin derivative and contains chemical compounds derived m wood pulping. It may be purchased as a powder or a water solution containing 50 rcent solids. The water solution was used on this job because of the economics of pping and handling on the job site. It is composed of surface active chemicals and, refore, acts as both a wetting and cementing agent. The cementing agent itself is uble in water and to some extent can be washed out by rain. The treated surface ap- rs quite dark, assuming a dark brown color when treated with the more concentrated utions.

An effort was made to place some of the various dilutions of each type of material in as of different dust intensity. Two controls were also established to determine the nparative water costs.

CONSTRUCTION

All of the test sections were placed on August 12, 13 and 14, 1957. The various parations were stored on the job site in trailers and spreading was performed with tandard asphalt distributor.

The materials were pumped into the distributor from the storage trailer and water was led to produce the desired dilution. In the case of the lignin and asphalt emulsion, concentrate was first pumped into the distributor and the water added. With the res- us petroleum product, the concentrate was added after the water in order to reduce foaming. In all cases, no extra agitation was necessary for blending. The water wa under high pressure and dropped from an 8-in. standpipe through the manhole on top of the distributor into the tank. This caused a pronounced surging action which aide in mixing. It should be noted that both the lignin and resinous petroleum product hav additives incorporated in the concentrate for promoting a very rapid mixing in high dilutions.

One of the difficult field decisions in the use of any material is to determine the best spread rate for the particular soil being treated. On this job, the median area between stations 180± and 400± had been extensively watered over a period of about one month. The movement of the water trucks had compacted the material in the top ¼ to ½ in., and coupled with the fact that the major portion of the median was on a fa slope, indications were that a runoff might be expected during spreading operations.

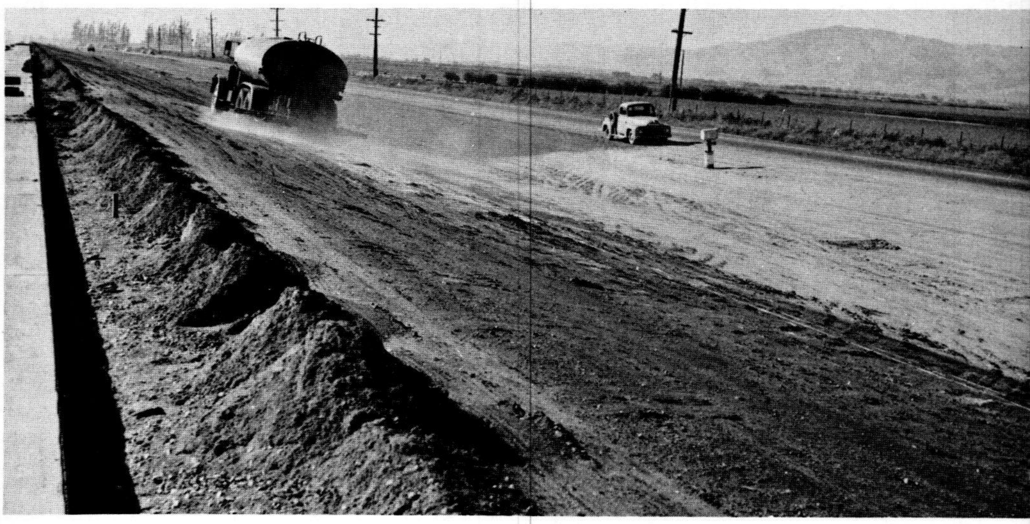


Figure 3. Typical appearance of various dilutions of dust controlling agents immedi ately after first spread of 0.25 gal per sq yd on median slope. None or only ver slight runoff was noted on the first pass.

Preliminary trials, with a hand watering can, indicated that definite penetration coul be obtained, with a minimum of runoff, when a maximum of 0.25 gallon per sq yd wa spread in a single application. Recommendations from the producers literature indi cated that 0.5 gallon per sq yd should be satisfactory in preventing dust formation on an area not subjected to traffic movements. Therefore, it was decided to spread a to tal of 0.5 gallon per sq yd with two passes of 0.25 gallon per sq yd. This procedure was followed throughout all of the test sections. Some difficulties were encountered establishing the spread rate and a number of trials were necessary, inasmuch as the available charts for spreading the more viscous asphalts proved useless with these di lutions. However, final calculations indicate that an average of 0.56 gallon per sq y was spread in the lignin and resin test sections and 0.54 gallon per sq yd in the aspha emulsion sections. The final spread rates show that calibration trials are necessary when using normal oil or asphalt spreading equipment. These trials only required a short delay on the morning of the first day.

The normal procedure was to make the first pass forward, back up along the test section, and then immediately spread the second pass over the same strip. On the first pass there was very little runoff on the slopes, and penetration was about ⅛ to in. with the second pass showing a slight runoff (Fig. 3). On one of the sections attempt was made to increase the total spread by a third and fourth pass over the er portion of the slope of the median. There was considerable runoff and it was dent that 0.5 gallon per sq yd was the maximum amount that would properly pene- te and stay on the slope. It is interesting to note, that good penetration with no run- was achieved with the same spreading procedure in the area between station 114 180± where a rather rocky, granular material was encountered. There were no iculties in spreading operations with the various dilutions of the three products ap- ed in the test sections.

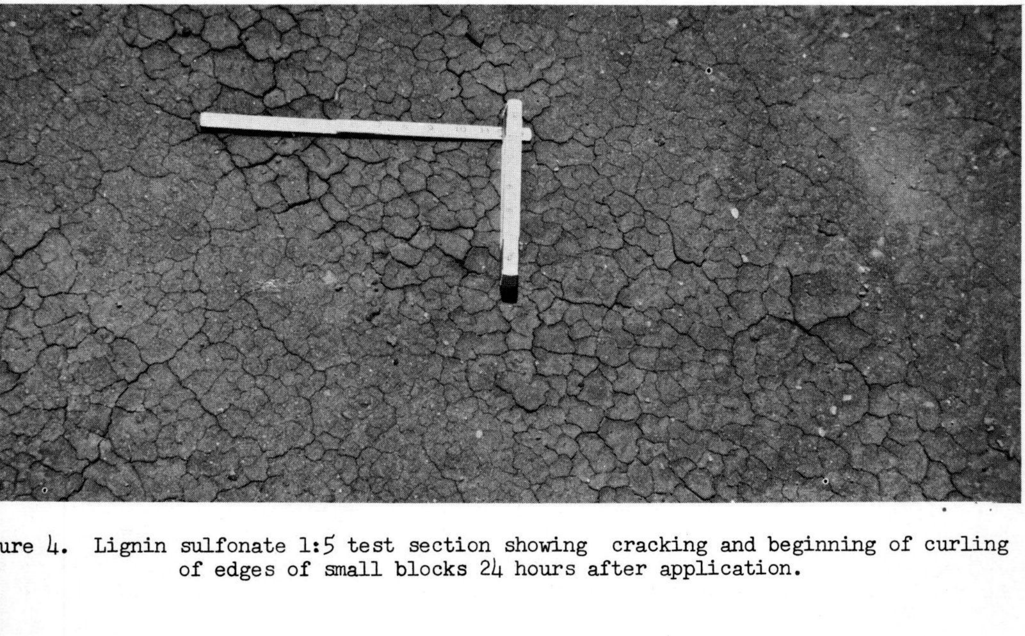
EVALUATION STUDIES

Approximately 24 hours after completion of spreading, the test sections were eval- ed on the basis of surface appearance and dust formation (Fig. 6).

The lignin-treated sections of 1:5 and 1:10 dilutions, were a darkish brown shortly er spreading. They tended to form a definite crust on the surface which began to ck and curl slightly in some areas, about 24 hours after spreading (Fig. 4). The etration appeared to vary from 1/16 to 3/16 in. After 48 hours the crust tended to crack small blocks roughly 3- by 3-in., with a tendency of the edges of the blocks to l upwards. These blocks did not, however, separate from the underlying material no dust or distress was noted in the sections with winds averaging 20 to 25 mph.

The petroleum resin sections gave a yellowish brown appearance after completion spreading. Penetration was the same as in the lignin sections; but no cracking or ling was noted, even in the 1:4 dilution, indicating a uniform cohesiveness of the ated soil.

he asphaltic mixing emulsion, 1:10 dilution turned very black, shortly after spread- . The asphalt appeared to have formed a mat at the surface although it was quite ntly bound to the underlying material, indicating at least a partial penetration of the ulsion prior to separation of the asphalt. At the end of 24 hours the section was in ellent condition. There was no cracking or curling of the thin asphaltic membrane ering the surface. The original plan also called for a 1:20 dilution of emulsion, the quantity available did not provide a sufficient volume and the final dilution was



ure 4. Lignin sulfonate 1:5 test section showing cracking and beginning of curling of edges of small blocks 24 hours after application.

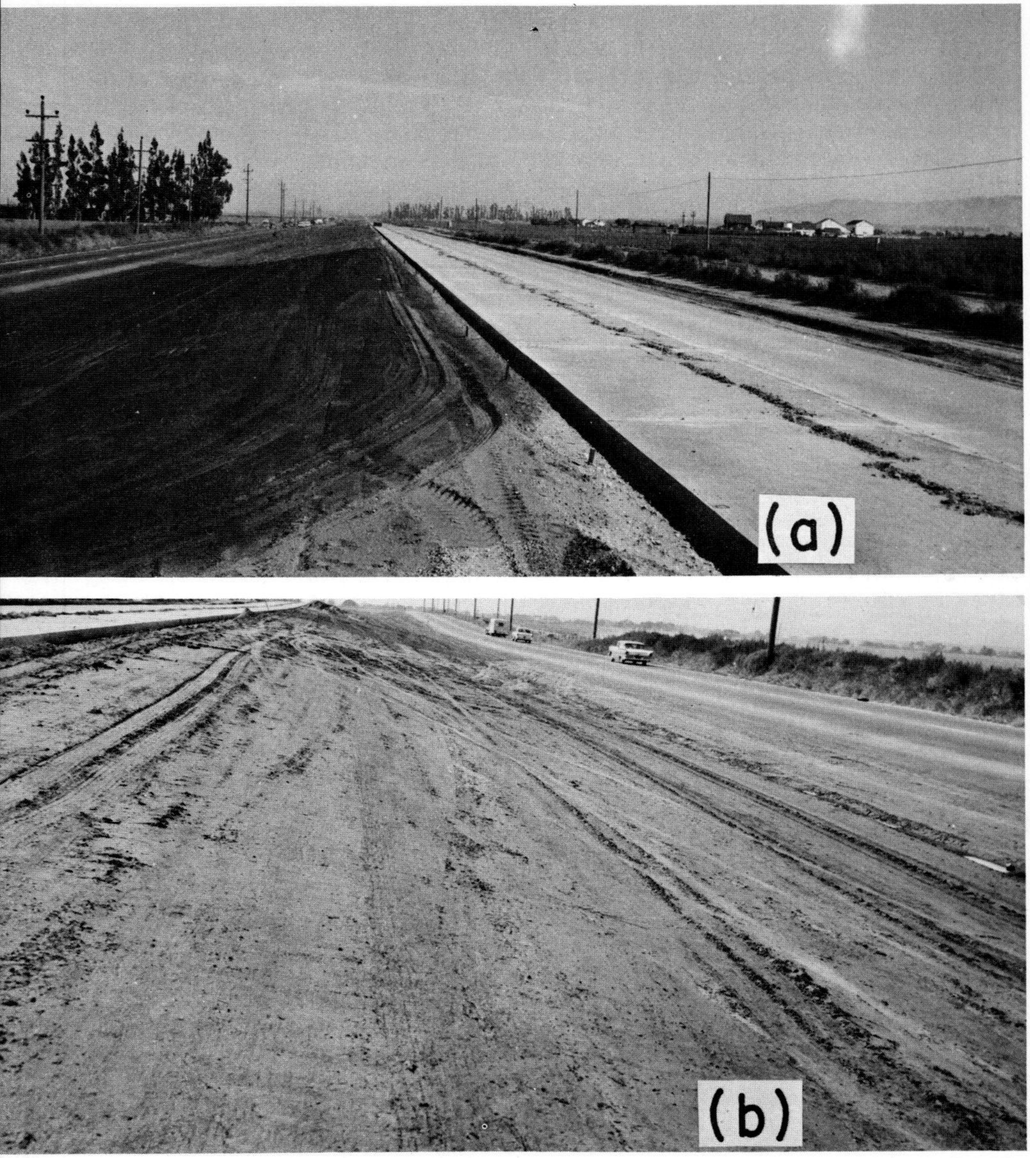
1:30. It was surprising to note that this high dilution provided a darkish brown surf with quite good penetration. One could definitely tell that a treatment had been performed. After 24 hours the section looked good with no cracking or curling.

As mentioned previously, the median strip on Monday morning, August 12, was i a tightly compacted condition. Water had been placed on the median during the nigh and it was decided to stop all sprinkling in order to secure maximum penetration of products under test. Because of problems involving transfer of the concentrates to storage trailers and checking of spread rates, only one section, the lignin 1:5, was completed by noon. About 11 a.m. the wind began to blow and by 1 p.m. the wind v locity was averaging around 20 mph, with gusts up to 25 mph. By 1:30 p.m. visibil on the adjacent travelway had been reduced by dust from the median so that lights w required. The photographs shown in Figure 5 indicate the extent of dust formation.

Figure 5. Typical dust formation on untreated sections 5 hours after cessation of w tering operations. Wind speed 20-25 mph. Note reduced visibility on existing trave way on left side of photograph. Median had previously been heavily watered for mo than a month and tightly compacted by movement of water trucks.

All of the test sections were completed by noon on Wednesday, August 14. At 11 a.m. the wind again started and reached Monday's velocity by 1:00 p.m. No water been applied to any of the test sections, except the controls, after spreading was co pleted and although high winds persisted throughout Wednesday afternoon and evenin there were no signs of dust. Photographs shown in Figure 7 show the absence of du over the treated sections. It may be concluded that dust formation had been comple eliminated by all of the various dilutions of the preparations placed in the test secti

Generally, to justify the use of dust controlling agents, it is necessary to prove t they are more economical than the normal method of sprinkling with water. To pre an economic analysis for this job, two control sections were established for the pur of determining watering costs during the evaluation period. The resident engineer maintained cost records on watering of the control sections during a 23-day period, lowing completion of the treated sections. During this interval 138,000 gallons of w were applied to Control No. 1, station 265-380; and 104,000 gallons to Control No. station 200-220. At a price of $1.75 per 1,000 gallons of water, including supplyin hauling and spreading, an average figure of $0.0009 per sq yd per day for cost of wate the control sections, during the 23-day evaluation period is obtained. This cost figure



gure 6. Appearance of test sections, 24 hours after application: (a) asphalt mixing ulsion—1:10 section in foreground, petroleum resin 1:7 section in background; (b) untreated section in foreground, lignin sulfonate 1:10 section in background.

nsiderably lower than the watering costs of the entire median during a 10-day period st prior to spreading the test sections. The cost of watering the entire median of out 161,000 sq yd (total treated sections plus two controls) as furnished by the resint engineer amounted to $450 per day, or

$$\frac{450.00}{161,000} = \$0.0028 \text{ per sq yd per day.}$$

is apparent that the controls were not watered as much as equivalent areas prior to eatment. This was due to the fact that the dust generated from the comparatively nall areas of the two controls, was less hazardous to traffic than the dust generated om the original total median area. It therefore appears reasonable to assume that the figure obtained from the cost of sprinkling the entire median during the 10-day p od just prior to treatment should be used for economic comparisons.

The total costs per sq yd for the various dilutions used are given in Table 2. Th direct comparison with the cost of watering is also given on the basis of the number days that each test section must provide against dust formation before the costs of t agents used equals that of applying water. It will be noted that this "break even" pe od varies from 4 to 14 days.

An evaluation study was made on September 18 and 19, 1957, or 35 days after pla ment. At this time, all of the test sections that had not been disturbed by construct activity, were in good condition and were fully effective in preventing dust formation without additional watering. A very small amount of water was being used on areas jacent to shoulder construction where blading operations had torn up the surface and along the shoulder edge of the existing travelway. No water had been applied to any disturbed areas of the treated sections since the original spreading operations. On basis of the 35-day evaluation period, the saving by treatment amounted to $391.49 day for each day beyond the "break even" point for any specific dilution. The $391. figure was obtained by multiplying the total treated area, 139,819 sq yd, by the aver water cost per sq yd per day for the 10-day period prior to treatment. In other wor if the most expensive treatments, lignin 1:5 or resin 1:4, had been placed over all o the test sections, then at the end of 14 days of no watering, such treatment would ha paid for itself. The continued protection up to the evaluation period of 35 days had saved $8,221 ($391.49 x 21 days).

Figuring one of the less expensive treatments with an average "break even" point 8 days, the actual saving amounted to $349.49 x 27 days or $9,436.

The surface appearance of the test sections was such that it could reasonably be a sumed they would give additional protection from dust formation for at least another

TABLE 2

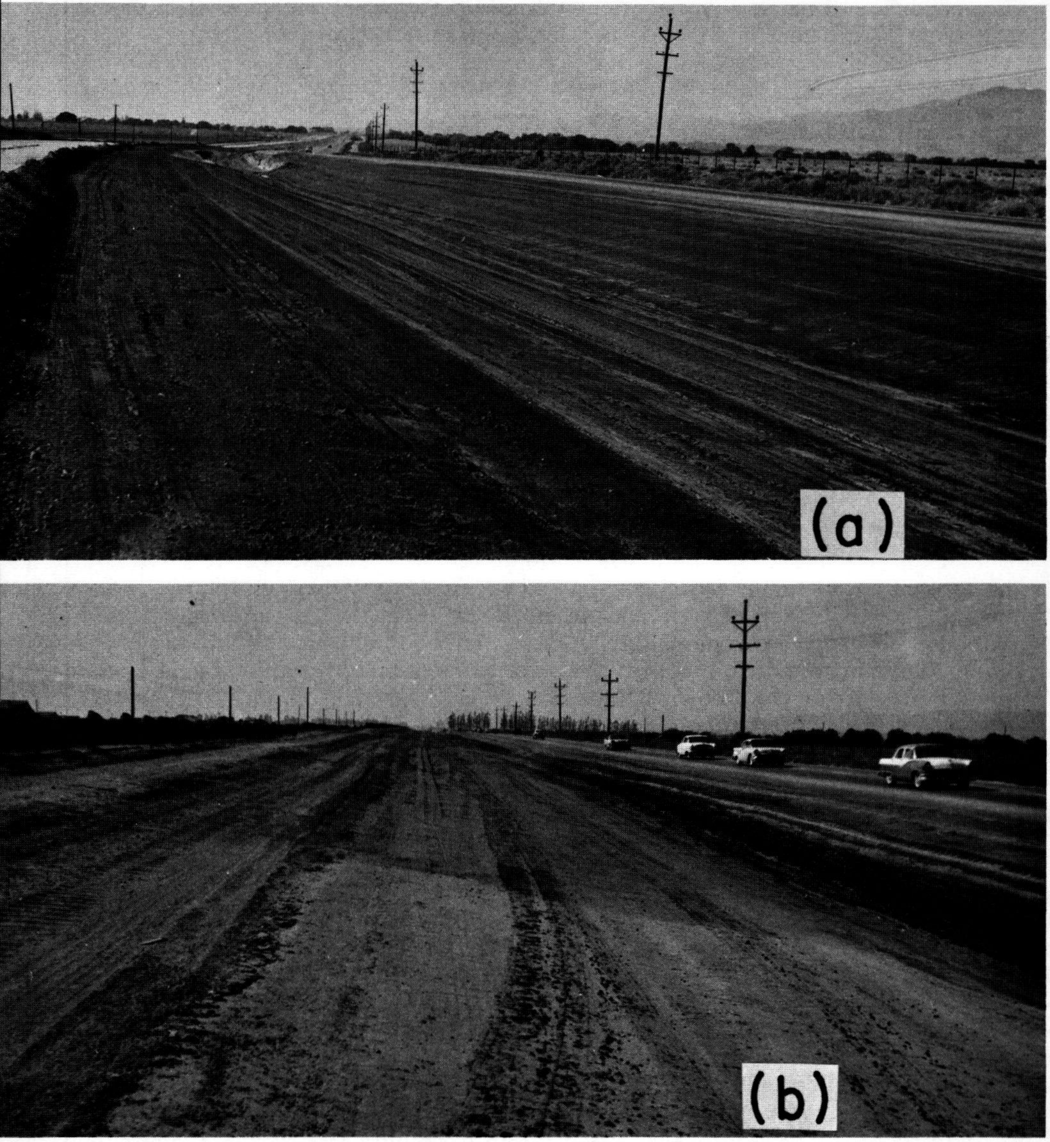
COST ANALYSIS FOR DUST CONTROLLING AGENTS USED ON CONTRACT 58-5TC4F, ROAD V-MON-2-D

Dust Binder Type	Dilution	Total Spread Area (sq yd)	Spread Rate (gal per sq yd)	Cost of: Material Conc.	Cost of: Water	Cost of: Spreading	Total	Cost of Dust Controlling Agent (per sq yd)	Cost of Water Per Sq Yd per day Prior to Treatment	Break Ev Point fo Dust Contro in Day
Petroleum resin compound	1:4	22,677	0.56	$749.30	$17.78	$ 90.71	$857.79	$0.038	$0.0028	14
	1:7	9,750	0.56	201.19	8.37	39.00	248.56	0.026	0.0028	9
	1:10	32,000	0.56	480.56	28.51	128.00	637.07	0.020	0.0028	7
Lignin sulfonate	1:5	25,117	0.56	850.87	20.51	100.47	971.85	0.039	0.0028	14
	1:10	22,500	0.56	415.64	20.06	90.00	525.70	0.023	0.0028	8
Asphaltic mixing emulsion	1:10	12,750	0.54	188.43	10.96	51.00	250.39	0.020	0.0028	7
	1:30	14,966	0.54	78.56	13.69	59.86	152.11	0.010	0.0028	4

days or even longer if not disturbed by construction equipment. On this basis, the a tual saving to the state could have amounted to $349.49 x (50-14) days or $12,582 f the most expensive treatment and $349.49 x (50-8) days or $14,679 for the less exp sive treatment.

The survey made after 35 days indicated that all of the various sections were per- forming in a satisfactory manner, with the same general wind conditions encountere prior to treatment (Fig. 8). The general appearance of the test sections at that tim may be summarized as follows:

1. Lignin sulfonate 1:5 and 1:10 dilutions still appeared quite dark, with quite ext sive cracking and curling in the 1:5 section. This cracking and curling had not caus separation of the crust from the underlying layer and no evidence of dust formation v present.
2. All of the various petroleum resin dilutions showed a remarkable change in co



igure 7. Lack of dust formation over treated sections: (a) asphalt mixing emulsion :30—shows an area where the most severe dust formation was encountered on the job; (b) sphalt mixing emulsion, 1:10 background, petroleum resin 1:7 foreground. These photographs were taken approximately 48 hours after treatment with a wind velocity of 20-25 mph. Compare with photograph shown in Figure 5.

rom the freshly sprayed surface. The sections gave no appareance of having been sprayed and showed no signs of cracking or curling as noted in the lignin section. On close inspection one could detect yellowish-like streaks where runoff had occurred during the second pass. Although these sections had assumed the color of the native soil he treatment provided full protection against dust formation at wind velocities exceeding 25 mph.

3. There was no major change in the appearance of the emulsion sections. There was no evidence of drying out or cracking and curling.

The condition of the various sections definitely indicated that protection in undisturbed areas would continue for a much longer period of time.

PLANT GROWTH

The treatment of median strips and other areas where future plant or grass growth is planned has raised the question as to whether dust controlling agents will tend to retard or destroy such growth. In the case of the three agents discussed here, there are reasons for believing that such growth might be accelerated. The lignin compound is water soluble and is relatively easily decomposed by soil bacteria, thereby enriching the soil. In fact, the only evidence of growth on the median strip was in the lignin sections where small amounts of alfalfa had started to grow, 35 days after application. Previous studies by the Air Force with the resin compound on a 20-acre semi-desert location clearly showed an improvement in growth of vegetation when compared with an adjacent untreated control area. All of these agents, including the highly diluted asphaltic mixing emulsion tend to prevent the upper layer of soil from drying out, and because of their dark color, they tend to increase the soil temperature near the surface, thus providing more favorable growing conditions.

OTHER APPLICATIONS

One of the important factors in the decision to use a special product to alleviate dus is the amount and price of water considered necessary for dust abatement on any specific project. If the water requirement is quite low, then the "break even" period may be extended beyond the period requiring dust control and any material may prove too expensive compared to water costs, although some monetary value should be assigned to the complete absence of dust at all times.

Consideration must also be given to other conditions on the job site. It should be stressed that, in using any kind of dust control, one must realize the marked differences between conditions encountered in undisturbed areas such as are cited in this report and those found on a haul road or detour under traffic. A single treatment, that may adequately protect an undisturbed area, may provide only a temporary protection for a heavily traveled haul road or detour. In most cases, where serious dust formation is encountered, the soil is extremely fine and if dust is present at the time of treatment, the actual penetration may be quite low even in high dilutions. The movement of vehicles, especially heavily loaded construction equipment, will disturb and break up the surface layer and immediately generate dust. It is, therefore, logical to expect that more frequent treatments will be necessary in such cases, and that the various agents will perform differently. While crust formation has been found to be of no disadvantage in controlling wind erosion, the absence of a brittle surface crust may be advantageous in traveled areas.

Some preliminary studies have been performed on the use of dust binder agents on haul roads and detours. An economic analysis is complicated by the amount and type of traffic and the necessity for retreatment as the original treated surface is abraded or raveled away.

On one contract traffic was routed through the job over 7.8 mi of untreated rock base. Prior to the start of paving operations a severe dust problem had developed and considerable water was required. Although such watering reduced the hazard to traffic, there were times when there was sufficient dust in the air to be annoying. Therefore, mixing-type emulsion was tried, by treating six sections varying from 1,000 to 10,000 ft in length. A 1:10 mixture was used and applied from the water truck at about the same speed as with normal watering operations. On three of the sections two spreads were made and on the other three only one spread. The penetration on all sections was quite good and the results were effective at the start and one of the two water trucks previously used was eliminated.

Three weeks later the entire area required blading because of raveling, and watering was again required on all of the treated sections. However, it was noted that the water requirements on these reworked treated areas were considerably less than before the application of the diluted emulsion.

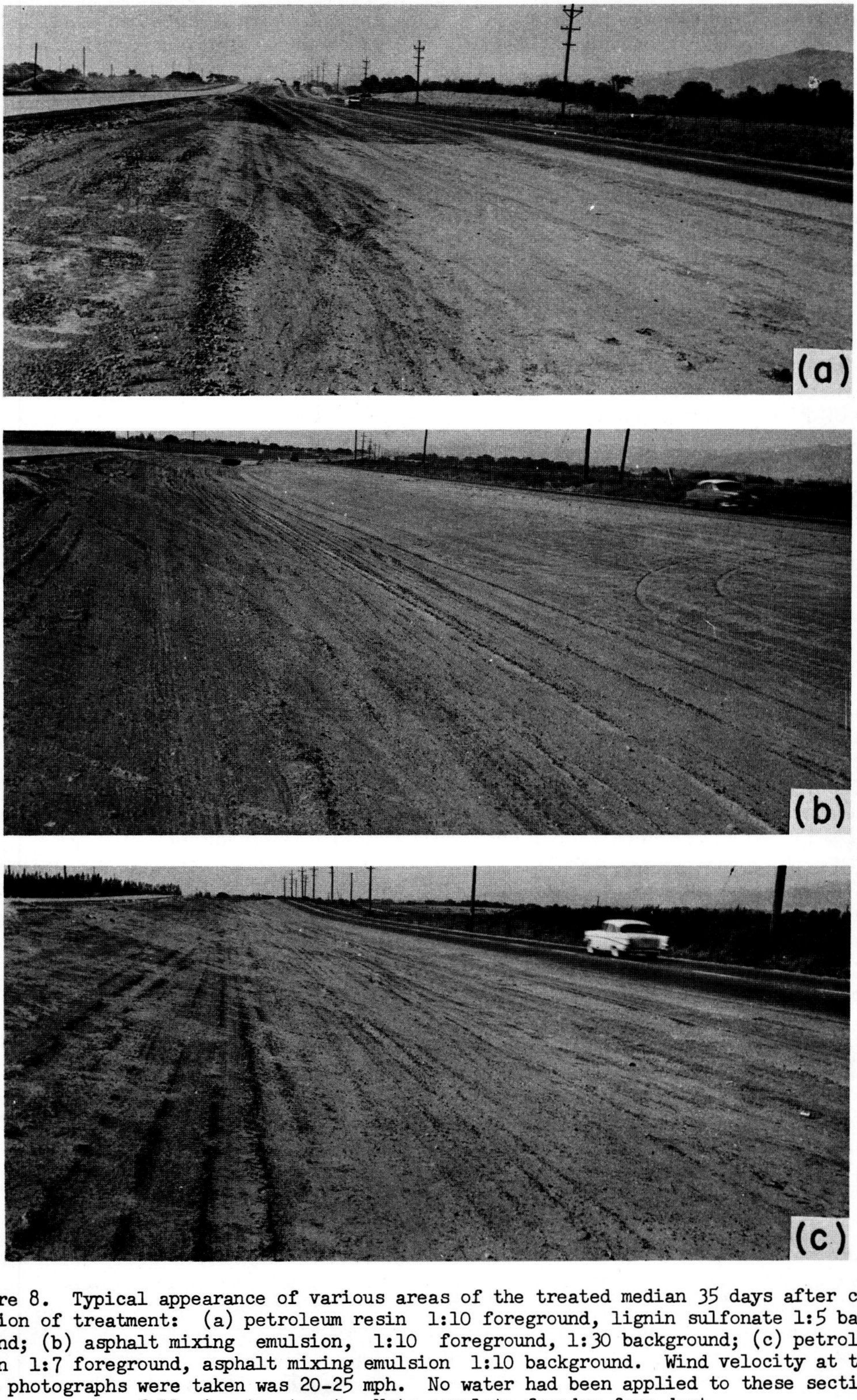


Figure 8. Typical appearance of various areas of the treated median 35 days after completion of treatment: (a) petroleum resin 1:10 foreground, lignin sulfonate 1:5 background; (b) asphalt mixing emulsion, 1:10 foreground, 1:30 background; (c) petroleum resin 1:7 foreground, asphalt mixing emulsion 1:10 background. Wind velocity at time that photographs were taken was 20-25 mph. No water had been applied to these sections following treatment. Note complete freedom from dust.

The following conclusions were drawn by the resident engineer on the basis of his observations: "A conservative estimate in the amount of water saved by using the diluted emulsion also showed a savings in money since water on this contract was pricec at $1.50 per M-gallons. In addition other benefits were realized, such as more effec tive control of dust at all times, day and night, and less annoyance to traffic."

On another contract, approximately 6,000 ft of processed selected material had bee laid. This section was being used by the contractor for heavy hauling operations and was adjacent to homes and several orchards where choice fruit was grown. Although the surface was extensively watered, many complaints were received because of dust raised by the passage of trucks. The 6,000-ft stretch was divided into three 2,000-ft sections. One of the sections was established as a control and watered at the same rate as previously used. On one section an initial treatment of 0.7 gallons per sq yd of a resinous petroleum product in 1:7 dilution was applied and after penetration follow by 0.3 gallons per sq yd of the same dilution. On the other treated section a mixing-type asphaltic emulsion was used at the same application rates, but with a 1:10 dilutio The heavy volume of traffic required periodic retreatment. In the case of the resin se tion these treatments involved an application of 0.2 gallons per sq yd of either a 1:10 c 1:20 dilution and the asphalt emulsion was applied at the same rate, but at a 1:10 dilution.

The study was continued for a period of 83 days, during which there was no rain, a traffic included not only heavy-duty trucks, but also DW20 scrapers. During this inte val the petroleum resin section was treated seven times and the emulsion section thre times. However, the comparison is complicated by the fact that in four of the seven treatments the resin binder was applied at 1:20 dilution, whereas a 1:10 dilution was f the asphalt emulsion.

During the 83-day test period the total costs for each section were: water control = $496, resin = $588, and emulsion = $279. The emulsion treatment showed a definite saving based on the relatively high cost of water at $1.50 per M-gallons.

The resident engineer, who observed the areas during the test period, states, "Bot materials were more effective than water in controlling dust. In both treated sections the development of dust was very slow, allowing the scheduling of a supplemental appli cation well in advance of critical dustiness."

The additional advantages of more positive control of dust and the fact that watering alone may not adequately control dust formation indicates that in some cases a dust controlling agent should be used even though the total cost is higher.

Experience to date indicates that the decision to use special products on haul roads must be made on the basis of each individual job and economical considerations may not be the most important factor.

CONCLUSIONS

The studies outlined in this report clearly indicate the economic advantage of treati dust areas whether undisturbed by equipment or traffic or consisting of haul roads witl some type of agents other than water. In the first cited example, Contract 58-5TC4F the saving to the state by using the preparations is estimated to be about $10,000. Th various agents tested can be easily diluted with water and spread with normal construc tion equipment. The additional advantage of more positive dust control indicates that i some cases a dust controlling preparation should be used, even though the total cost is somewhat higher than watering.

ACKNOWLEDGMENTS

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