ARIZONA DEPARTMENT OF TRANSPORTATION

SOIL EROSION AND DUST CONTROL ON ARIZONA HIGHWAYS

Part II Laboratory Testing Program

Report: ADOT-RS-10-141-II

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INTERIM FINAL REPORT

SOIL EROSION AND DUST CONTROL ON ARIZONA HIGHWAYS

PART II - LABORATORY TESTING PROGRAM

by

HASSAN A. SULTAN

Submitted to

The Arizona Department of Transportation
Highways Division
Phoenix, Arizona 85007

for

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16. Abstract

Forty-six commercially available chemicals were tested in this study. Laboratory testing included subjecting specimens of a dune sand, treated with spray-on chemicals, to simulated wind velocities up to 90 mph. Specimens of compacted granitic soil, treated with either a spray-on or a mixed-in application of the chemicals, were subjected to simulated traffic abrasive forces under simulated tire pressures up to 60 psi.

Selected chemical treatments were subjected to various environmental-durability conditions before testing. Durability conditions included freeze-thaw cycles, wet-dry cycles, rainfall-dry cycles, and variation of curing temperatures.

Based upon the results of this laboratory testing phase, several chemical stabilizers were selected for applications in a large scale field testing program

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KEY WORDS: Chemical Stabilization, Soil Stabilization, Erosion Control, Dust Control, Wind Erosion, Traffic Erosion, Rain Erosion.

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CHAPTER 1

INTRODUCTION

This laboratory testing program was designed to consider and evaluate several parameters in erosion control of trafficable and non-trafficable areas. These parameters include, method of application, cost and rate of application, curing period, curing temperatures, wind velocities, traffic pressure intensity, freezing and thawing cycles, rain erosion, and wet-dry cycles. Response to chemical treatment is determined by measuring the amounts and rates of erosion (soil losses) of the treated soil as compared to untreated soils.

Scope

The scope and objectives of this laboratory investigation are multifold, and are outlined as follows:

1. Screen the commercial market of soil stabilizing agents by contacting major manufacturers, suppliers, and formulators to obtain materials which they recommend as potentially suitable for soil erosion control. Such materials had to satisfy certain requirements regarding their physical and chemical properties along with cost limitations.
2. Select two soils for use in the laboratory tests. A wind-blown sand (dune sand) to be used for wind erosion studies, and a subgrade soil that was used by the Arizona Department of Transportation (ADOT) to be used for traffic erosion studies.
3. Determine the capability of the collected chemicals in reducing wind erodibility of the dune sand using a spray-on application.
4. Determine the capability of the collected chemicals in reducing traffic erodibility of the compacted subgrade soil using spray-on and mixing applications.
5. Determine the durability of the stabilized soils under adverse environmental conditions. These tests are to be limited to the

best performing chemicals as manifested in the preliminary tests. The durability tests are to include wind and traffic erosion tests under freeze-thaw conditions, wet-dry cycles, rain-dry cycles, and variable curing temperatures.

6. Select several chemicals, at the conclusion of the laboratory testing program, to be used in the field tests.

Scope Limitations

The scope of additives to be used include all types of chemical stabilizers available on the market, however, conventional stabilizers such as portland cement, lime, sodium and calcium chlorides, and asphalt are not included. Some petroleum products that can be evaluated as chemical stabilizers were included and tested in this program.

The dilution rate and method of application of the chemicals as used in this study conform as close as possible with the recommendations given by the suppliers. Deviation from these recommendations were made, in some cases, to conform with the cost limitations imposed by the selection criteria.

Accordingly, optimization of chemical properties of the additives and optimization of cost-benefit ratios are excluded from this study. Such optimization studies should constitute a separate investigation in which the potential of very few selected chemicals can be investigated for stabilization of various soils having a wide range of soil properties.

Finally, it is pointed out that the materials compared in this study were commercial items. They were not developed or manufactured to meet any particular Government specifications, to withstand the tests to which they were subjected, or to operate as applied during this study. Any failure to meet the objectives of this study is no reflection on any of the commercial items discussed herein or on any manufacturer.

CHAPTER 2

MATERIALS EVALUATION

The basic materials used in this laboratory investigation include the soils and the chemical additives. Other materials or equipment used in testing are discussed elsewhere under appropriate headings.

Selection of Soils

Four bulk soil samples were submitted by ADOT for evaluation and selection of a dune sand and a subgrade material. Two sand samples were submitted, one from the Yuma area and the second from the Holbrook area. Two subgrade samples were also submitted, one is a granitic soil from Apache Trail and the second is a volcanic type soil.

Physical and mechanical properties of these four soils were determined in the laboratory including specific gravity, grain size distribution, Atterberg limits, and compaction characteristics. Based on these tests, the Yuma sand and the Apache Trail granitic soil were selected for use in the laboratory phase of the study and about 4-tons of each were delivered by ADOT.

Yuma Sand

This is a wind blown dune sand obtained from Yuma, Arizona. The grain size distribution of this sand is shown in Figure 1. The calculated uniformity coefficient of approximately 2.5 indicates that the sand has a very uniform gradation. Most of the sand grains fall in the size range of 0.1 to 0.3 mm. Physical and mechanical properties including specific gravity, plasticity, and compaction characteristics, are given in Table 1. The chemical analysis including its pH value, different salt and ionic concentrations, and the amount of organic matter is shown in Table 2.

An x-ray diffraction study of the sand was performed as a means of identifying the principal mineral constituents of the soil. The analysis

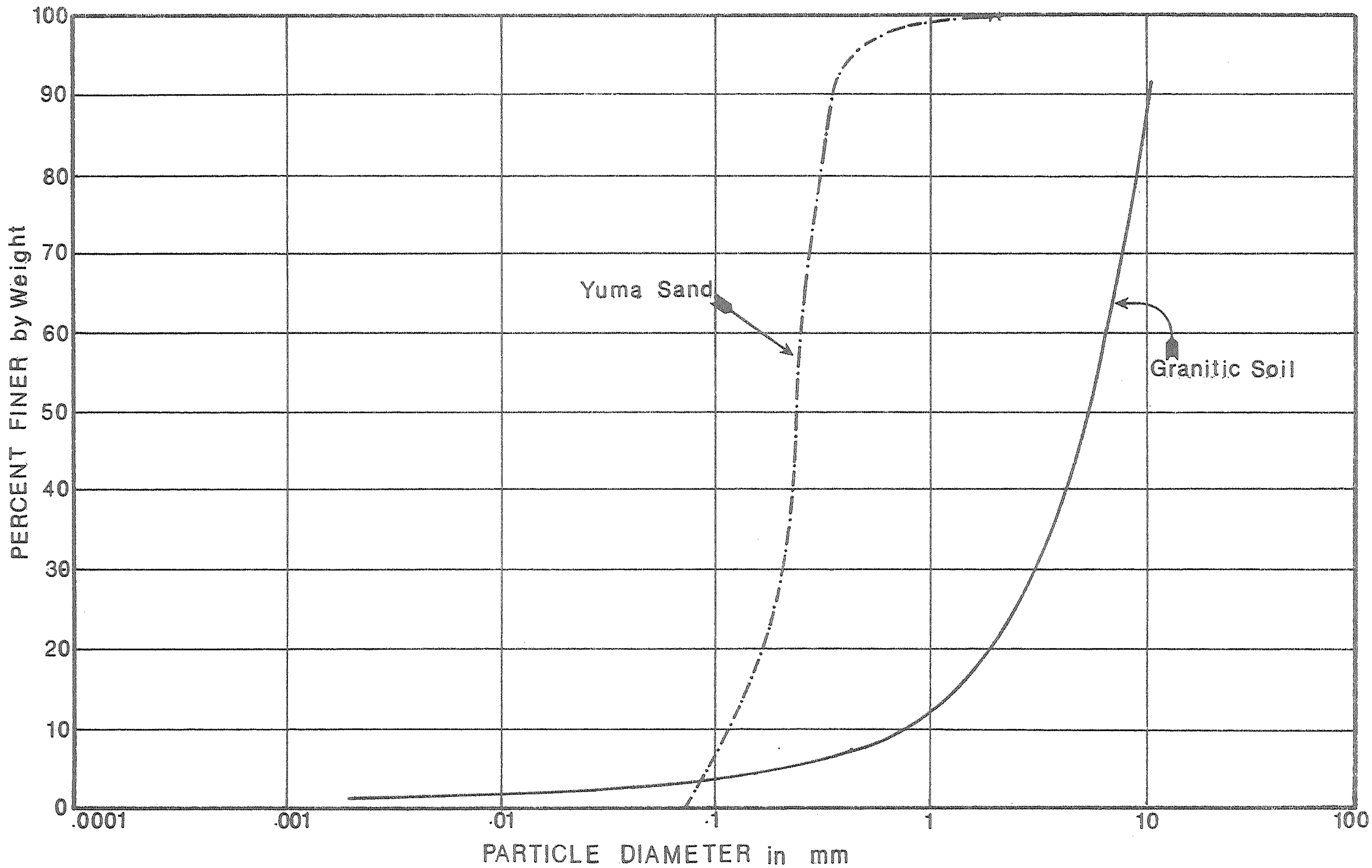

FIGURE 1 - GRAIN SIZE DISTRIBUTION CURVES

TABLE 1 - INDEX PROPERTIES OF SOILS USED

Index Property	Yuma Sand	Granitic Soil
Specific Gravity	2.67	2.70
Liquid Limit %	--	36
Plasticity Index %	NP	5
St. AASHTO, δ max. pcf	105.5	122.3
St. AASHTO, W opt. %	11.8	12.0
Mod. AASHTO, δ max. pcf	110.3	128.5
Mod. AASHTO, W opt. %	11.2	9.4

TABLE 2 - CHEMICAL ANALYSIS OF SOILS

Chemical Property	Yuma Sand	Granitic Soil
pH Value	8.4	6.9
Soluble Salts, ppm	126	98
Nitrates (NO_3), ppm	6.4	5.0
Phosphates (PO_4), ppm	5.8	2.25
Organic Matter, %	0.064	0.22

showed the following minerals to be present in a decreasing order: Quartz (about 80%+), Feldspar (plagioclase), Mica (illite and muscovite), Chlorite, Kaolinite and Calcite.

Granitic Soil

This is a subgrade soil obtained from Apache Trail area (Mile Post 201.2 maintenance pit) and was being used for subgrade construction. The grain size distribution of this soil is also shown in Figure 1. Physical and mechanical properties of this soil are presented in Table 1. Based on these results, the granitic soil is classified as (A-1-a) soil. The chemical analysis including its pH value, different salt and ionic concentrations, and the amount of organic matter, is shown in Table 2. X-ray study of this soil indicated the presence of the following minerals in a decreasing order: Feldspars (orthoclase and plagioclase), Quartz, Dolomite, Mica (illite, muscovite), and Chlorite-Smectite mixed-layer minerals.

Selection of Chemicals

To screen the commercial market of soil stabilizing agents, major manufacturers, suppliers, and formulators were contacted for the purpose of obtaining materials which they recommend as potentially suitable for soil erosion control. Each agency contacted was provided with a letter explaining the scope of the project along with the specific requirements the chemicals should incorporate. These requirements are summarized below under "Stabilizers Criteria". A copy of the material forwarded to these agencies is included in Appendix A.

Stabilizers Criteria

The solicited stabilizers, as applied were required to be products that are non-toxic, non-flammable, non-corrosive to allow easy storage, are easy to handle and apply, and unharmful to plant or animal life should they leach out of the treated soil. The products should be economical to use with a material cost limit not exceeding 15 cents per square yard for stabilization of non-trafficable areas such as embankments and open spaces. Material cost limit of 75 cents per square yard was set as the ceiling value for stabilization of trafficable unpaved roads. These were the proposed initial stabilization costs, with annual maintenance costs not exceeding 5 cents and 10 cents per square yard for non-trafficable and trafficable areas, respectively.

Chemical Solicitation

Approximately 170 manufacturers and suppliers were contacted for the purpose of soliciting chemical stabilizers. Six months later another solicitation letter was sent to the 75 manufacturers and suppliers who did not respond to the first request. A copy of the second letter of solicitation is also given in Appendix A. A list of the companies which were contacted is also given as Table A-1, in Appendix A. Fifty-two companies declined to participate for one reason or another but the majority declined due to unavailability of chemicals that satisfy the criteria given. Seventeen solicitations were returned by U.S. mail apparently for lack of forwarding addresses. Thirty-six companies accepted to participate in the project and forwarded their chemicals. We have received and worked with 45 chemicals. A list of the chemicals used in this project is given in Appendix B with a separate sheet for each chemical giving its name, manufacturer, properties, cost, the rates of dilution and of application used in the laboratory study, along with general remarks and comments, if any. The chemical listed as No. 46 is essentially a mixture of two other chemicals, No. 17 and No. 14, as discussed elsewhere in this report.

CHAPTER 3

LABORATORY TESTING PROGRAM

The laboratory tests conducted were designed to evaluate the capability of the stabilized soils to resist wind erosion and traffic erosion forces, as applicable. Accordingly separate tests were designed for wind erosion and for traffic erosion. This chapter includes a detailed description of these various test methods.

Wind Erosion Tests

The wind erosion tests were conducted to evaluate the degree of stabilization imparted by spraying the chemicals on a wind-blown dune sand when subjected to various wind velocities. Specimens tested for wind erosion studies were not subjected to traffic simulation.

Accordingly, for these tests only the Yuma sand was used, and only a spray-on application of the chemicals was used.

Test Procedure

The molds used in this test, and actually for most other tests, were 6-inch diameter and 2-inch high. The molds were machined from a 6-inch schedule-40 polyvinyl chloride (PVC) pipe. This type of pipe was selected since most chemicals do not bond too well to its surface. The following steps were followed in performing this test:

1. Enough sand was oven dried then allowed to cool down to room temperature under a plastic cover. An empty mold was then placed on top of a 8 in. X 8 in. piece of 3/4-inch thick plywood. The weights of both the mold and the plywood were recorded. A consistent weight of dry sand (1435 gms) was poured into the mold. This particular weight was decided upon after averaging the weights of sand needed to loosely fill up 10 molds. This weight gives an average loose density of about 96.6 pcf. In order to obtain a homogenous sample, another plywood cover was placed on top of the mold and then the mold with the sand in

it confined between the two plywood covers was turned over end for end several times. The mold was then placed flat on a horizontal bench and the top plywood cover removed. The surface of the loose sand inside the mold was level and ready to be sprayed. The weight of the plywood support, the mold and the sand was recorded. Figures 2 through 4 show the steps of placing the sand in the mold.

2. A plywood sheet 18 in. X 18 in. with a 6-inch diameter hole in the center was placed on top of the sample such that the surface of the sand was totally exposed through the center hole. This sheet was used to avoid spraying the mold and the plywood over which the mold was placed with the chemicals.
3. The chemical to be sprayed was prepared at the dilution rate recommended and was placed into the tank of a spray gun. The spray guns used were the bleeder-type with air blowing through the gun constantly. The trigger controls only the flow of the chemical. The air pressure used was varied from one chemical to the other depending on the viscosity of the solution. The nozzles were adjusted to give a uniform spray. The dilution and rate of application for each chemical is given in Appendix B.
4. The surface of the specimen was then sprayed evenly with the chemical. The weight of the sprayed specimen was monitored every now and then until the required amount of chemical spray was sprayed on the surface. The specimen was then removed and placed in a curing room at constant temperature of 70°F and 50% relative humidity. Figure 5 shows a specimen being sprayed; and a section of the curing room is shown in Figure 6.
5. For each chemical treatment three sets of specimens were prepared for each wind velocity used. One set was cured for 1 day, one for 3 days, and one for 7 days. The final weight of the specimen at the end of curing was then recorded.
6. At the end of the specified curing period the specimen was transferred from the curing room and placed in front of a wind blower. Two wind blowers were set up with attachments as shown in Figure 7. The plexiglass attachments were designed to deliver

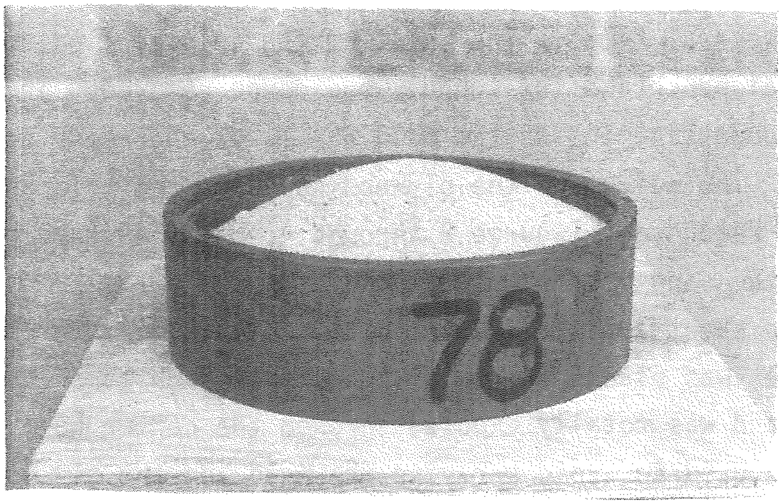

FIGURE 2: LOOSE SAND POURED INTO THE MOLD

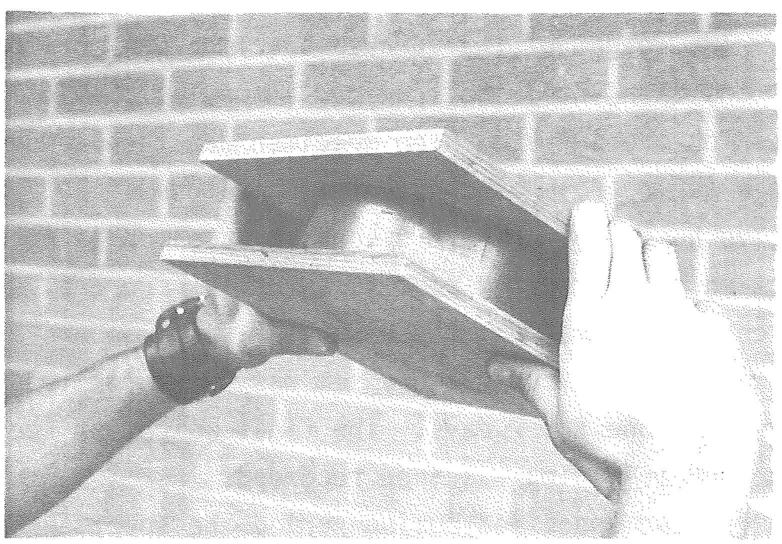

FIGURE 3: TURNING MOLD OVER END FOR END

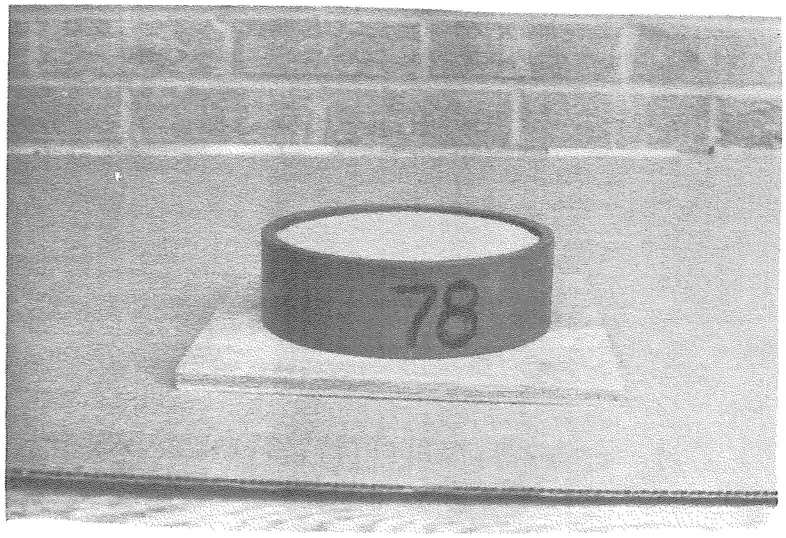

FIGURE 4: LOOSE SAND WITH LEVEL TOP SURFACE

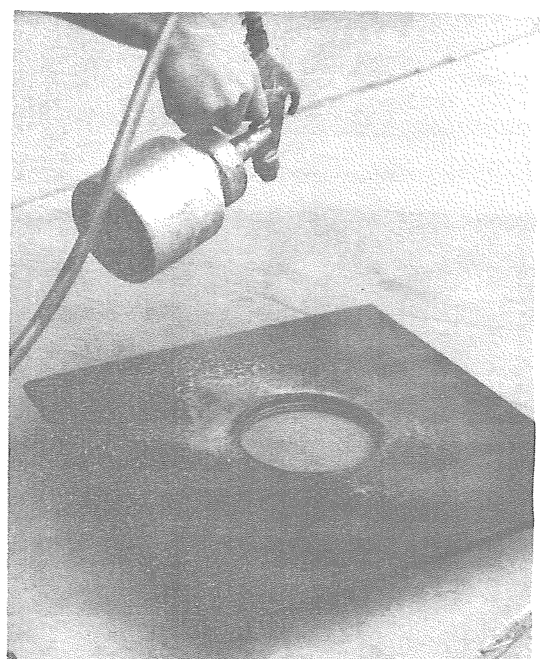

FIGURE 5: SPRAY-ON APPLICATION OF CHEMICALS

FIGURE 6: SPECIMENS IN THE CURING ROOM

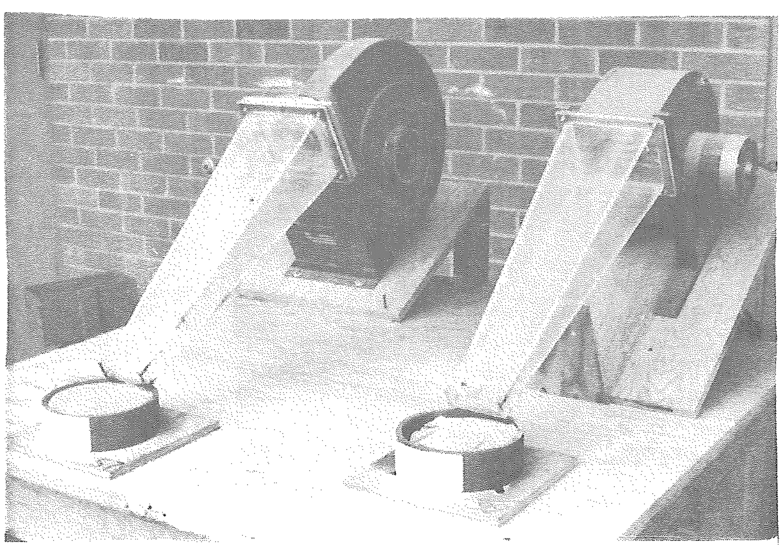

FIGURE 7: WIND BLOWER TEST SET UP

a wind velocity of 45 mph using the small blower and a wind velocity of 90 mph using the larger blower. A test period of 3 minutes was selected since it was more than the time required for water-sprayed specimens to completely erode away.

7. At the end of the wind test period, each specimen was reweighed and the difference from the weight after curing was considered as weight of sand particles eroded away by wind. A small sample was taken at the end of the wind test to determine the moisture content. The moisture content was used to correct the amount of sand loss to a dry-weight basis. The ratio of this corrected weight loss to the original weight of the dry sand placed in the mold (1435 gms) in percent, was considered as the "erosion percent".
8. Duplicate specimens were tested for each test condition, and the resulting average erosion percent was reported as the corresponding value for the particular specimen condition.

Test Results

The results of this wind erosion test are summarized in Table 3 and include the chemical name and the erosion percent under 45 mph and 90 mph wind velocities for specimens cured for 1, 3, and 7 days. Also included is the cost of chemical application per square yard. This cost refers to the cost of the chemical only; F.O.B. the location of the manufacturer or supplier. Later on in the report both chemical costs (F.O.B. supplier and F.O.B. Tucson, Arizona) are reported for selected chemicals. The rates of application used in this test are given in summary sheets for the chemicals in Appendix B, along with the depths of penetration observed in each case. It is pointed out that the thickness of the surface crust developed after curing did not necessarily equal the depth of penetration observed at the application. In most cases the full 2 inch thickness of the specimen was moist after the spraying application, but the cured crust thickness ranged from 1/8 inch to 3/4 inch. Figure 8 displays two crusts for two different chemicals. The mode of failure of most specimens that did not withstand the wind was due to break up of the surface crust and a subsequent rapid erosion of the loose sand below. For such behavior, specimens are marked "F" in Table 3 to denote failure.

TABLE 3: WIND EROSION TEST RESULTS (Sand, 70°F Curing)

Chem. No.	Chemical Name	Erosion, Percent						Cost ¢/yd2 F.O.B. Supplier
		45 mph			90 mph			
		1-day	3-day	7-day	1-day	3-day	7-day	
0	Water	0.23	3.21	F	1.60	F	F	--
1	Soil Stabilizer 801	0.07	0.07	0.0	5.27	0.07	0.0	11.6
2	Compound SP-301	0.0	0.0	0.0	0.0	0.07	0.0	10.4
3a	White Soil Stabilizer	0.0	0.0	0.0	0.0	0.0	0.21	5.2
3b	White Soil Stabilizer	0.0	0.0	0.0	0.0	0.0	0.0	10.3
4	Stikvel P-65	0.0	0.0	0.0	F	F	F	15.0
5	Velsicol W-617	0.0	0.0	0.0	F	F	F	14.6
6	Redicote E-52	Not Recommended by Supplier						
7	Aerospray 70	0.0	0.0	0.0	0.0	0.0	0.0	11.4
8	Aerospray 52	0.0	0.0	0.0	0.0	0.0	0.0	13.0
9	Curasol AE	0.0	0.0	0.0	0.0	0.0	0.0	12.4
10a	Polyco 2190	0.0	0.0	0.0	0.0	0.0	0.0	14.5
10b	Polyco 2190	0.0	0.0	0.0	0.0	0.0	0.0	14.5
11a	Polyco 2460	0.0	0.0	0.0	0.0	0.0	0.0	14.5
11b	Polyco 2460	0.0	0.0	0.0	0.0	0.0	0.0	14.5

TABLE 3 - Continued

Chem. No.	Chemical Name	Erosion, Percent						Cost ¢/yd^2 F.O.B. Supplier
		45 mph			90 mph			
		1-day	3-day	7-day	1-day	3-day	7-day	
12	Orzan GL-50	0.0	0.0	0.0	0.0	0.0	0.0	3.3
13	Surfaseal	0.0	0.0	0.0	0.0	0.0	0.0	13.3
14a	Formula 125	F	F	F	F	F	F	10.8
14b	Formula 125	F	F	F	F	F	F	12.2
15	Enzymatic SS-1	Not Recommended by Supplier						
16a	RTD-SS-X	0.14	0.07	44.0	2.8	F	F	0.8
16b	RTD-SS-X	0.14	8.3	F	28.5	F	F	1.6
17	Norlig-41	0.0	0.0	0.0	0.0	0.0	0.0	4.0
18	Dust Bond 100	0.0	0.0	0.0	0.0	0.0	0.0	12.0
19	Sodium Silicate #9	0.0	0.0	0.0	0.0	0.0	0.0	5.0
20a	Petroset SB	0.0	0.0	0.0	0.0	0.0	0.0	11.5
20b	Petroset SB	0.0	0.0	0.0	0.0	0.0	0.0	14.0
21a	Coherex	0.0	0.0	0.0	0.0	0.0	0.0	2.9
21b	Coherex	0.0	0.0	0.0	0.0	0.0	0.0	4.6
21c	Coherex	0.0	0.0	0.0	0.0	0.0	0.0	6.9
21d	Coherex	0.07	0.0	0.0	0.07	0.07	0.0	7.5
22	Soiltex	0.0	0.0	0.0	0.0	0.0	0.14	5.0

TABLE 3 - Continued

Chem. No.	Chemical Name	Erosion, Percent						Cost ¢/yd^2 F.O.B. Supplier
		45 mph			90 mph			
		1-day	3-day	7-day	1-day	3-day	7-day	
23	Thermoset 401	Not Recommended by Supplier						
24	Enzymatic SS-2	Not Recommended by Supplier						
25	Dresinate DS-60W-80F	0.0	0.0	0.0	0.0	0.0	0.0	8.5
26	Paracol 1461	0.0	0.0	0.0	0.0	0.0	0.0	9.8
27	Terrakrete #2	0.0	0.0	0.0	0.0	0.0	0.0	11.1
28	Terrakrete #1	0.0	0.0	0.0	0.14	0.0	6.21	3.0
29a	M-Binder	Too Viscous to Spray						9.3
29b	M-Binder	0.0	0.0	0.0	2.23	F	F	9.3
30	Triton X-114SB	0.0	0.0	0.0	0.0	0.0	12.47	5.9
31	Corexit 7740	0.35	F	F	6.76	F	F	0.1
32	Super Crete-100	0.21	0.0	0.0	F	0.14	5.78	8.0
33	Aliquat H226	F	2.93	30.52	F	F	F	11.0
34	Petroset RB	Too Viscous to Spray						
35	Biobinder	0.0	0.0	0.0	0.0	0.0	0.0	12.0
36	Surfax 5107	0.35	5.59	F	0.21	F	F	0.45
37a	Dust Control Oil	0.0	0.0	0.0	0.0	0.0	0.0	7.5
37b	Dust Control Oil	0.0	0.0	0.0	0.0	F	F	3.8

TABLE 3 - Concluded

Chem. No.	Chemical Name	Erosion, Percent						Cost‡ ¢/yd² F.O.B. Supplier
		45 mph			90 mph			
		1-day	3-day	7-day	1-day	3-day	7-day	
38	Dust Stop	0.0	0.0	0.0	0.0	0.0	0.0	7.9
39	Aquatain (Liquid)	0.0	0.0	0.0	0.0	0.0	0.0	8.8
40	Aquatain (Powder)	0.0	0.0	0.0	0.0	0.0	0.0	5.2
41	Foramine 99-194	0.0	0.0	0.0	0.0	0.0	0.0	13.6
42	Plyamul 40-153	0.0	0.0	0.0	0.0	0.0	0.0	12.4
43	Ashland Oil Stabilizer	0.0	0.0	0.0	F	F	F	15.0
44	Compound SP-400	0.0	0.0	0.0	0.0	0.0	0.0	11.0
45	Foramine 99-434-2	0.0	0.0	0.35	0.0	0.72	0.0	14.0
46	Norlig-41 + F.125	0.0	0.0	0.0	0.0	0.0	0.0	9.1

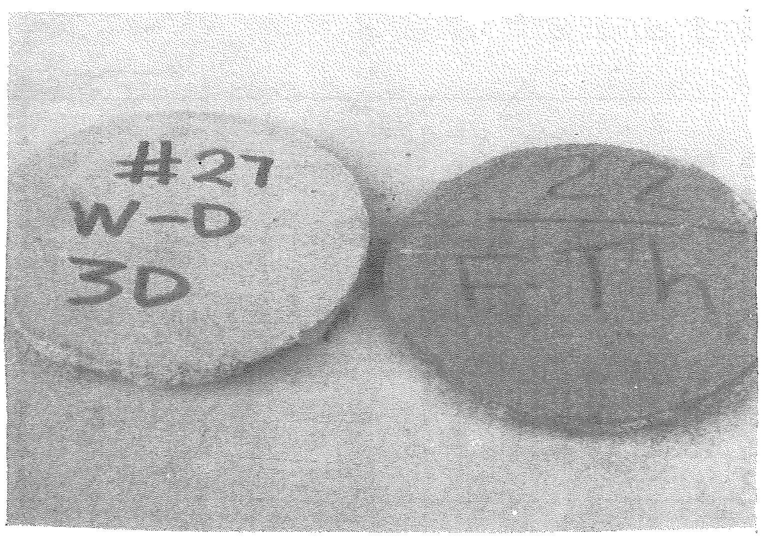

FIGURE 8: SURFACE CRUST OF SPRAYED-ON SAND SPECIMENS

Discussion of Test Results

The results given in Table 3 indicate that many of the chemicals applied were quite effective in reducing or eliminating erosion of the dune sand under wind velocities of up to 90 mph. Four of the chemicals available were not recommended by their manufacturers for use with wind erosion studies, these are: Redicote E-52, Enzymatic SS-1, Thermoset 401, and Enzymatic SS-2. Accordingly the data for these chemicals are not reported even though some were successful in eliminating wind erosion losses.

Twenty-seven chemicals were selected based on their performance in this test to undergo further testing to evaluate the durability of their stabilization potential after being subjected to adverse environmental conditions. It is pointed out that, at this stage in the study, the manufacturer of chemical No. 10 (Polyco 2190) advised us that the chemical has been discontinued and no additional supply was available for any further testing. The durability tests included freeze-thaw cycles, wet-dry cycles, rain-dry cycles and variation of curing temperatures. These tests are discussed below.

Environmental-Durability Tests

For these tests the sand samples were cured for 3 days, subjected to the durability test specified and then tested under wind velocities of 45 and 90 mph. Most of the durability tests caused an increase in the moisture contents of the specimens, therefore, at the end of the durability testing the specimens were allowed to air-dry to constant weight before being subjected to wind tests. This procedure was adopted to test the wind erodibility at the dry state which is most vulnerable to wind erosion, without the additional stabilizing effect of capillary moisture.

Freeze-Thaw Cycles

1. Specimens were prepared and sprayed with the chemicals as described before.
2. Specimens were allowed to cure for 3 days in the environmental room (70°F, 50% R.H.).

3. Specimens were then placed for 6 hours in a 70°F, humid room where access to moisture was available through the continuous moisture spray and vapor in the humid room. No direct impact of water spray was allowed on the specimens. This procedure was used in lieu of placing the specimens on moist pads which was difficult to attempt since the sand in the molds was quite loose below the surface.
4. Specimens were subjected to 3 freeze-thaw cycles. Each cycle consisted of 6 hours in a freezing room at 10°F and 18 hours in a 70°F humid room. At the end of the third cycle each specimen was allowed to air-dry in the environmental room to a constant weight, which was recorded.
5. Duplicate specimens were tested under 45 mph wind velocity and another set was tested under 90 mph, as described before. The weight of the specimen was recorded after the wind test and any loss was recorded. A final water content sample was taken to determine the moisture content after the wind test and to correct the amount of erosion loss to a dry weight basis. For each specimen, the ratio of this corrected weight loss to the original dry weight of the sand in percent was calculated and the average value was reported as the erosion percent.

Wet-Dry Cycles

1. Specimens were prepared and sprayed with the chemicals as described before.
2. Specimens were allowed to cure for 3 days in the environmental room (70°F, 50% R.H.).
3. Specimens were then subjected to 3 wet-dry cycles. Each cycle consisted of 6 hours in a 70°F humid room and 18 hours in the environmental room. At the end of the third cycle each specimen was left in the environmental room to dry out to a constant weight, which was recorded.
4. Duplicate specimens were tested under 45 mph wind velocity and another set was tested under 90 mph, as described before. The weight of each specimen was recorded after the wind test and

any loss was recorded. A final water content sample was taken to determine the moisture content after the wind test and to correct the amount of erosion loss to a dry weight basis. For each specimen, the ratio of this corrected weight loss to the original dry weight of the sand in percent was calculated and the average value was reported as the erosion percent.

Rain-Dry Cycles

The machine used to simulate rainfall is known as the "Rotadisk Rainulator". The Rainulator gives a combination of relatively low intensity rain (varying from close to zero to more than 60 inches per hour) with realistic drop sizes and high impact velocity. This is accomplished through the use of a pressure controlled high capacity nozzle and slotted-rotating disks to regulate the impact velocity and intensity. The Rainulator was built in 1971 at the Civil Engineering Department based upon the original drawings by Morin et al (1970) as modified by Sultan (1971). The operational principals of the Rainulator have been presented previously elsewhere, and a summary is given in Appendix C.

In this study an average rain intensity of 2.38 inches per hour was used. The specimens were placed on a 14° slope with the horizontal; this slope was chosen based on previous studies which indicated this slope to cause high erosion amounts, El-Rousstom (1973). The procedure followed for this test is described below.

1. Specimens were prepared and sprayed with the chemicals as described previously.
2. Specimens were allowed to cure for 3 days in the environmental room (70°F, 50% R.H.). After this curing period the weights were recorded.
3. Specimens were then subjected to 3 rainfall-dry cycles. Each cycle consisted of 1 hour of rain at 2.38 inches per hour and 23 hours in the environmental room (70°F, 50% R.H.). Figure 9 shows specimens being tested in the rainfall simulator.
4. At the end of the third cycle, each specimen was left in the environmental room to dry out to a constant weight, which was then recorded. This period was usually about 3 days.
5. Duplicate specimens were then tested under 45 mph wind velocity

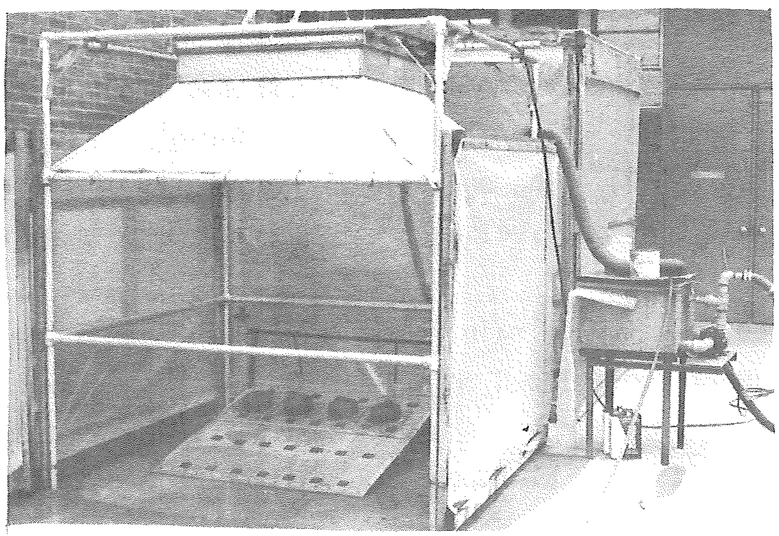

FIGURE 9: ROTATING DISK RAINFALL SIMULATOR

and another set was tested under 90 mph, as described previously. The weight of the specimen was recorded after the wind test and any loss was recorded. A final water content sample was taken to determine the moisture content after the wind test and to correct the amount of erosion loss to a dry weight basis. The ratio of the corrected weight loss during the wind test to the original dry weight of the sand in percent is the erosion percent due to wind. The corrected weight loss during the 3 rainfall-dry cycles presented as a ratio of the original dry weight of the sand is the erosion percent due to rain. Both values are reported as described later on under "Test Results".

Variation of Curing Temperature

Since the environmental room temperature of 70°F was generally used for the curing of the test specimens, it was decided to evaluate the effect of temperature during curing on the wind erosion control capability of the cured specimens. This test was conducted as follows:

1. Specimens were prepared and sprayed with the chemicals as described before.
2. One group of specimens was allowed to cure for 3 days in a controlled environment of 40°F at 50% R.H. At the end of the curing period the weights of the specimens were recorded.
3. Another identical group of specimens was allowed to cure for 3 days in a closet-size convection oven with temperature ranging between 140°F-145°F as measured continuously by thermometers. At the end of the curing period the weights of the specimens were recorded.
4. Duplicate specimens from each group were tested under 45 mph wind velocity, and another set was tested under 90 mph, as described previously. The weight of each specimen was recorded after the wind test and any loss was recorded. A final water content sample was taken to determine the moisture content after the wind test and to correct the amount of erosion loss to a dry weight basis. For each specimen, the ratio of this corrected weight loss to the original dry

weight of the sand in percent was calculated and the average value was reported as the erosion percent.

Test Results

The results of the wind erosion tests on specimens subjected to the various environmental-durability conditions described above, are presented in Table 4. Separate listings are given for tests conducted at 45 mph and at 90 mph wind velocities. The erosion percent values reported pertain to the corrected soil loss during the wind tests. In the rain-dry cycles, both the erosion percent due to wind and the erosion percent experienced during the 3 cycles are reported; the first number refers to the former while the second number refers to the latter, respectively.

Discussion of Test Results

Out of the 27 chemicals selected for this phase of the testing program 20 chemicals appeared to successfully endure the various environmental conditions to which they were subjected and afford a good measure of wind erosion control under the test conditions.

As discussed previously, the cost of the chemical treatment for all these chemicals was held at a cost below 15 cents per square yard. However, due to the large number of chemicals passing the tests performed, it was decided to look into the possibility of reducing the cost of the chemicals to about one-half that amount. This was also in agreement with the cost figures being looked at during this time by the Property Management Division of the Arizona Department of Transportation.

It is pointed out that based on the results given in Table 4, the rain-dry cycles proved to be the most severe type of durability test since it generally resulted in higher erosion than the other environmental-durability conditions.

Wind Erosion Tests-Reduced Rates

As discussed above, the amount of sprayed-on chemical was reduced such that the cost of the chemical treatment will not exceed 7.5 cents per square yard (cost of chemicals FOB suppliers). This was achieved through the reduction of the application rate, increasing the dilution ratio, or both. The dilution rates and the rates of application of the

TABLE 4: WIND EROSION AFTER DURABILITY TESTS (Sand, 3-day Cure)

Chem. No.	Chemical Name	Erosion Percent, at 45 mph						Cost ¢/yd^2 F.O.B. Supplier
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	
0	Water	0.07	3.21	F	F	F	F-46.8	--
2	Compound SP-301	0.0	0.0	0.42	0.56	0.0	9.8-16.5	10.4
3b	White Soil Stabilizer	0.0	0.0	0.28	0.14	0.0	1.2-40.3	10.3
7	Aerospray 70	0.0	0.0	0.0	0.0	0.0	0.0- 0.8	11.4
8	Aerospray 52	0.0	0.0	0.0	0.0	0.0	0.0- 2.56	13.0
9	Curasol AE	0.0	0.0	0.0	0.0	0.0	0.07-7.04	12.4
11b	Polyco 2460	0.0	0.0	0.0	0.0	0.0	0.07-2.85	14.5
12	Orzan GL-50	0.0	0.0	0.0	0.0	0.0	0.21-26.5	3.3
13	Surfaseal	0.0	0.0	0.0	0.0	0.0	0.0- 2.65	13.3
17	Norlig-41	0.0	0.0	0.0	0.0	0.0	3.48-25.5	4.0
18	Dust Bond 100	0.0	0.0	0.0	0.0	0.0	6.2-36.1	12.0
19	Sodium Silicate #9	0.0	0.0	0.0	0.0	0.0	0.56-8.22	5.0
20a	Petroset SB	0.0	0.0	0.0	0.0	0.0	0.0-1.95	11.5
21a	Coherex	0.0	0.0	0.0	0.0	0.0	0.0-12.5	2.9
21c	Coherex	0.0	0.0	0.14	0.07	0.07	0.14-13.2	6.9
22	Soiltex	0.0	0.0	0.0	0.0	0.0	0.21-25.3	5.0

TABLE 4 - Continued

Chem. No.	Chemical Name	Erosion Percent, at 45 mph						Cost ¢/yd^2 F.O.B. Supplier
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	
25	Dresinate DS-60W-80F	0.0	0.0	0.0	0.0	0.0	0.0-26.6	8.5
26	Paracol 1461	0.0	0.0	0.21	0.0	0.0	0.14-1.12	9.8
27	Terrakrete #2	0.0	0.0	0.0	0.0	0.0	0.07-18.4	11.1
35	Biobinder	0.0	0.0	0.0	0.0	0.0	0.14-17.6	12.0
37a	Dust Control Oil	0.0	0.0	0.0	0.07	0.0	0.0- 2.3	7.5
37b	Dust Control Oil	0.0	0.0	0.0	0.07	0.0	0.0- 10.5	3.8
38	Dust Stop	0.0	0.0	0.0	0.0	0.0	0.0- 8.64	7.9
39	Aquatain (Liquid)	0.14	0.0	0.0	22.3	0.0	F -28.9	8.8
40	Aquatain (Powder)	0.07	0.0	0.0	0.14	0.0	0.0-19.1	5.2
41	Foramine 99-194	0.0	0.0	0.0	0.0	0.09	0.0- 8.2	13.6
42	Plyamul 40-153	0.0	0.0	0.0	0.0	0.0	0.0- 0.76	12.4
44	Compound SP-400	0.0	0.0	0.0	0.0	0.0	0.0- 3.28	11.0
45	Foramine 99-434-2	0.21	0.0	0.0	0.0	0.0	0.14-20.1	14.0
46	Norlig 41 + F125	0.0	0.07	0.0	0.0	0.0	0.14-0.52	9.1

TABLE 4 - Continued

Chem. No.	Chemical Name	Erosion Percent, at 90 mph						Cost ¢/yd^2 F.O.B. Supplier
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	
0	Water	3.07	F	F	F	F	F -48.2	--
2	SP-301	F	0.07	F	F	9.62	35.8-17.3	10.4
3b	White Soil Stabilizer	0.0	0.0	0.56	0.63	0.0	9.76-39.4	10.3
7	Aerospray 70	0.0	0.0	0.0	0.0	0.0	0.14- 0.6	11.4
8	Aerospray 52	0.0	0.0	0.0	0.0	0.0	0.07-2.41	13.0
9	Curasol AE	0.0	0.0	0.0	0.0	0.0	0.14-8.34	12.4
11b	Polyco 2460	0.10	0.0	0.0	0.0	0.0	0.0- 3.28	14.5
12	Orzan GL-50	0.0	0.0	0.07	0.07	0.0	6.27-24.6	3.3
13	Surfaseal	0.0	0.0	0.25	0.07	0.15	0.21-2.41	13.3
17	Norlig-41	0.0	0.0	0.0	0.0	0.0	11.85-26.2	4.0
18	Dust Bond 100	0.0	0.0	0.0	0.14	5.8	47.87-35.9	12.0
19	Sodium Silicate #9	0.0	0.0	0.0	0.0	0.28	14.15-8.78	5.0
20a	Petroset SB	0.0	0.0	0.0	0.0	0.0	0.07-2.15	11.5
21a	Coherex	0.0	0.0	0.0	0.0	0.0	0.0-13.2	2.9
21c	Coherex	0.0	0.0	0.14	0.07	0.21	0.21-14.3	6.9
22	Soiltex	0.0	0.0	0.21	0.74	1.14	22.72-23.5	5.0
25	Dresinate DS-60W-80F	0.0	0.0	0.0	0.0	0.0	0.63-28.2	8.5

TABLE 4 - Concluded

Chem. No.	Chemical Name	Erosion Percent, at 90 mph						Cost ¢/yd^2 F.O.B. Supplier
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	
26	Paracol 1461	0.21	0.0	0.21	0.0	0.07	0.21-1.23	9.8
27	Terrakrete #2	0.0	0.0	0.0	0.0	0.0	0.21-17.0	11.1
35	Biobinder	0.0	0.0	0.0	0.0	0.0	44.4-16.5	12.0
37a	Dust Control Oil	0.07	0.0	0.0	0.07	0.0	0.07-2.9	7.5
37b	Dust Control Oil	0.0	F	F	F	F	0.0- 11.2	3.8
38	Dust Stop	0.07	0.0	0.21	0.0	0.0	0.0-8.85	7.9
39	Aquatain (Liquid)	0.21	0.0	0.14	F	0.0	F -28.4	8.8
40	Aquatain (Powder)	0.28	0.0	0.49	0.21	0.0	0.14-19.2	5.2
41	Foramine 99-194	0.07	0.0	0.0	0.0	0.14	0.07-7.9	13.6
42	Plymul 40-153	0.07	0.0	0.0	0.0	0.0	0.0- 0.78	12.4
44	Compound SP-400	0.0	0.0	0.0	0.0	0.0	0.0- 3.62	11.0
45	Foramine 99-434-2	0.70	2.72	0.0	0.0	0.28	0.49-19.2	14.0
46	Norlig 41 + F125	0.0	0.07	0.0	0.0	0.07	0.28-0.55	9.1

chemicals at the reduced rates are outlined in the Summary Sheets given in Appendix B. In addition to the 20 chemicals that successfully passed the environmental tests, four additional chemicals that did not actually perform too well were also included for the new testing using the reduced rates. These four chemicals are Dust Bond 100, Sodium Silicate #9, Soiltex, and Dust Control Oil. Dust Bond 100 and Soiltex were added to compare their results with other lignin-sulfonate based products. Dust Control Oil was added since at that time a field test was monitored by the principal investigator for the Property Management Division of ADOT and the results of that test indicated a high degree of dust control using this chemical; Sultan (1974). Sodium Silicate #9 was added since it passed all the tests except the rain-dry cycles.

Test Procedures - Reduced Rates

The test procedures outlined previously for the wind erosion test, the freeze-thaw cycles, the wet-dry cycles, the rain-dry cycles, and the variable curing temperature tests were followed for the specimens sprayed with the reduced rates of chemicals. The only difference was that only one set of specimens was used and tested at 90 mph only. The 45 mph set was not conducted due to time limitations and since the 90 mph test was more severe anyway.

Test Results - Reduced Rates

The wind erosion results of the reduced-rate specimens subjected to the various environmental-durability conditions are presented in Table 5. The erosion percent reported pertains to the corrected soil loss during the wind test. Under the rain-dry cycles two values of erosion percent are reported, the first is due to wind erosion, the second is due to rain erosion, respectively.

Discussion of Test Results

Out of the 24 chemicals used in the reduced-rate tests, 14 chemicals appeared to successfully endure the various environmental conditions to which they were subjected and afford a good measure of wind erosion control under the test conditions at 90 mph wind velocity. A selection criterion was arbitrarily set that eliminates any chemical treatment that resulted in an erosion percent due to wind equal to or greater than

TABLE 5: WIND EROSION AFTER DURABILITY TESTS - REDUCED RATES

Chem. No.	Chemical Name	Erosion Percent, 3-day Cure, 90 mph						Cost ¢/yd^2 F.O.B.	
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	Supplier	Tucson
0	Water	3.07	F	F	F	F	F-48.2	---	---
7	Aerospray 70	0.14	0.07	0.14	0.0	0.0	0.17-6.6	5.95	6.50
8	Aerospray 52	6.79	0.14	0.07	1.35	0.21	2.84-6.48	6.8	7.27
9	Curasol AE	0.07	0.14	0.0	0.0	0.07	7.05-11.25	6.2	6.55
11	Polyco 2460	0.14	0.14	0.07	0.0	0.07	0.0-5.3	5.8	8.13
12	Orzan GL-50	0.07	0.14	0.07	0.0	0.28	8.44-29.3	1.7	7.0
13	Surfaseal	0.0	0.0	0.07	0.14	0.21	0.28-4.3	6.3	6.78
17	Norlig-41	0.14	0.07	0.07	0.0	0.0	13.9-28.3	1.6	5.28
18	Dust Bond 100	F	3.7	1.46	F	F	55.7-33.8	6.0	6.0
19	Sodium Silicate #9	0.07	0.07	0.0	0.0	F	58.4-10.9	2.5	7.4
20	Petroset SB	0.0	0.0	0.0	0.07	0.0	0.0-3.55	5.8	6.61
21	Coherex	0.0	0.0	0.0	0.0	0.0	0.0-13.2	2.9	5.8
22	Soiltex	0.0	0.07	1.27	1.14	2.07	24.8-26.5	2.0	5.0
25	Dresinate DS-60W-80F	0.0	0.0	0.0	0.0	0.0	1.74-27.8	3.4	5.95
26	Paracol 1461	0.14	0.07	0.35	0.14	0.07	0.28-1.67	3.9	6.52
27	Terrakrete #2	0.0	0.0	0.0	0.0	0.0	0.28-20.4	5.6	6.26
35	Biobinder	0.56	0.0	0.0	F	0.0	44.1-24.6	5.8	6.32

TABLE 5 - Continued

Chem. No.	Chemical Name	Erosion Percent, 3-day Cure, 90 mph						Cost ¢/yd^2 F.O.B.	
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	Supplier	Tucson
37	Dust Control Oil	0	F	F	F	F	0.0-11.2	3.8	10.9
38	Dust Stop	0.0	0.0	0.0	0.0	0.0	0.07-9.2	2.6	3.36
40	Aquatain (Powder)	0.21	0.0	0.28	0.42	0.0	1.2-21.3	5.2	5.3
41	Foramine 99-194	0.0	0.0	0.0	0.14	0.07	0.28-9.3	6.8	10.11
42	Plyamul 40-153	0.42	0.14	0.0	0.0	0.42	0.07-0.77	5.5	6.73
44	Compound SP400	F	0.0	0.0	F	27.87	22.1-6.9	5.5	6.77
45	Foramine 99-434-2	0.0	0.0	0.0	2.65	2.58	1.74-21.4	7.0	10.4
46	Norlig 41 +F125	0.0	0.07	0.0	0.0	0.07	0.28-0.55	9.1	9.1

5 percent. As shown in Table 5, again the rain-dry cycles proved to be the most severe type of the durability test conditions since it generally resulted in higher erosion than the other environmental-durability conditions.

These 14 chemicals are:

Aerospray 70	Surfaseal
Petroset SB	Coherex
Dresinate DS-60W-80F	Paracol 1461
Terrakrete #2	Dust Stop
Aquatain (Powder)	Foramine 99-194
Plyamul 40-153	Polyco 2460
Foramine 99-434-2	Norlig 41 + F125

In addition three chemicals showed good performance in the laboratory except they had to be eliminated beyond this point since they exceeded the 5% erosion criteria set. These were: Aerospray 52, Curasol AE, and Orzan GL-50.

When contacted to deliver the necessary chemicals for the field application, the supplers of Polyco 2460, Foramine 99-434-2, and Plyamul 40-153 reported that these chemicals have been discontinued mainly due to lack of availability of basic ingredients during the energy shortage (January 1974). Aquatain (powder) was not considered for field testing since it was reported as a biodegradable product which would lose effectiveness with time. Dust Control Oil was added to those chemicals used in the field application due to its superior field performance in another study completed at that time, Sultan (1974).

It is pointed out that most of the lignin-base products, e.g. Orzan GL-50, Norlig-41 and Soiltex suffered their highest erosion after being subjected to the rain-dry cycles. This was expected (in a way) due to the usually high solubility of the lignin products.

An attempt to reduce the solubility of a lignin product (Norlig-41) was made by mixing the Norlig-41 solution with a solution of a water proofer (F-125) which has a sodium methyl siliconate as its major constituent. This mixture proved to be very successful in reducing the solubility of the Norlig-41, as shown in Tables 4 and 5. This mixture is used throughout the study as chemical No. 46.

The cost of treatment per square yard given in Table 5 indicates the cost of the chemical application (Chemical only) based on the chemical cost F.O.B. the supplier and F.O.B. Tucson, Arizona. It is pointed out that these costs reflect the chemical costs during the start of the project (January 1973).

Chemicals Selected for Field Test - Wind Erosion

Based on the test results and the discussion given above, eleven chemicals were used in the field test phase of this project. The rates of application selected were those reported for the reduced rate tests. The details of the field application and field tests will be given in another report.

The chemicals used in the field application, in addition to water (control section), are:

- Aerospray 70
- Petroset SB
- Terrakrete #2
- Foramine 99-194
- Dresinate DS-60W-80F
- Dust Control Oil
- Surfaseal
- Paracol 1461
- Dust Stop
- Coherex
- Norlig 41 + F125

Traffic Erosion Test - Spray Application

These tests were conducted to evaluate the degree of stabilization imparted by spraying the chemicals on compacted road surface in reducing the erosion of the road surface when subjected to the abrasive action of traffic. The spray treatment simulates a post-construction application for unpaved (dirt) roads where it may not be feasible to mix the chemical with the subgrade before compaction. The granitic soil was exclusively used in the traffic erosion tests.

Traffic Erosion-Abrasion Simulator

Originally it was intended to use an abrasion apparatus similar to that used in design of slurry seal (California test method No. 355B) or as modified by ADOT (Arizona test method No. 807). However after the apparatus was made it became evident that a mold size of 9 to 10 inches in diameter would have to be made out of heavy steel cylinders since there was no PVC cylinders of such diameters available on the market. A steel

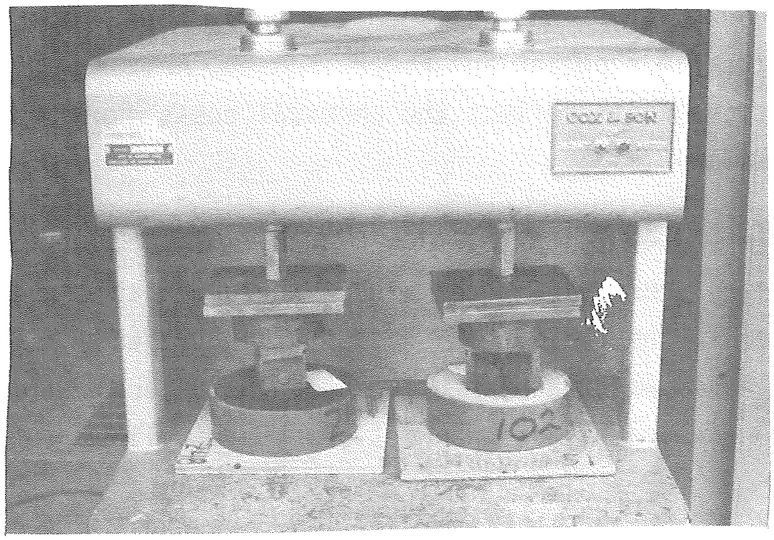

FIGURE 10: TRAFFIC ABRASION APPARATUS

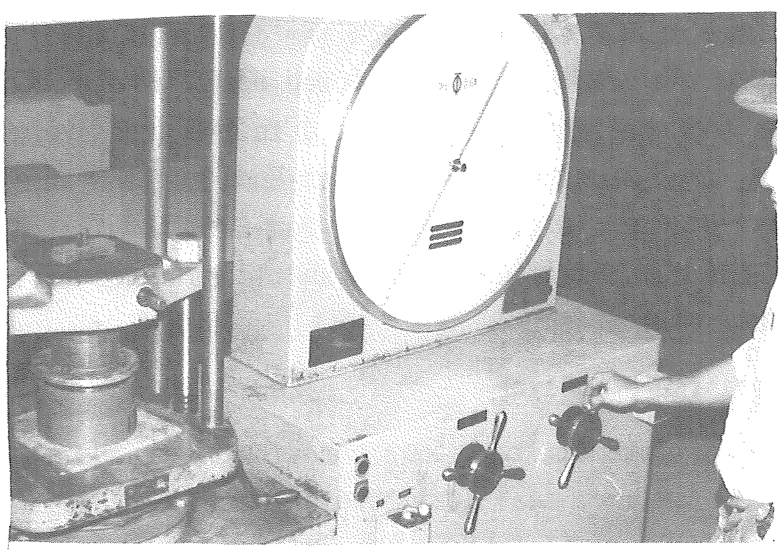

FIGURE 11: TRAFFIC EROSION SPECIMEN BEING COMPACTED

mold of this size proved to be quite heavy to handle especially due to the large number of specimens expected to be made.

In order to utilize the available 6-inch diameter PVC molds for the entire study, a smaller size abrasion apparatus was sought. An apparatus that was designed by R. A. Jimenez (1970) to evaluate abrasion characteristics of slurry seals, appeared to fit the requirements for this study. The apparatus was developed as a modification of a previous design reported by Gallaway and Jimenez (1963).

The apparatus consists of four rubber rollers 2-1/8 inches in diameter by 1/2-inch long mounted on a 1/2-inch shaft. The shaft is in turn mounted on a small steel frame made of 5/16-inch thick steel. Bolted to the top of the frame is a 4-1/2 inch long shaft, the lower 2-1/4 inches of this shaft is one inch in diameter while the top 2-1/4 inches part was machined to a 1/2-inch square cross section. This top portion of the shaft was inserted in the rotating sleeve of a mechanical bituminous mixer which can rotate at a speed of 30 rpm. Tare weights were machined out of steel cylinders and steel plates such that they can be slipped onto the small frame through the vertical shaft. The weights were calibrated such that resulting imprint contact pressure between the rubber rollers and a flat soil surface can be varied as 30 psi, 45 psi, and 60 psi. Figure 10 shows the traffic abrasion simulator apparatus loaded to 60 psi pressure intensity and placed on two soil specimens. It is pointed out that periodic replacements of the rubber rollers were made as the rubber layers tended to wear off.

<u>Test Procedure</u>

The same molds used for the wind erosion tests were also used for the traffic erosion tests. These were 6-inch diameter and 2-inch high PVC molds. The following steps were followed in performing this test:

1. Granitic soil was oven-dried for about 18 hours and then allowed to cool down to room temperature while covered with a polyethylene sheet. Enough soil for duplicate specimens was mixed with water in an electric mixer (Blakeslee Mixer) for ten minutes in order to ensure a uniform, homogeneous mixture. Sufficient water was used such that, allowing for evaporation losses, the moist soil would have a moisture content of 9.5 ± 0.5 percent. After the bowl was removed from the mixer, the soil in it was mixed

further using a hand scoop for two minutes. A wet towel was placed over the bowl until the soil was ready to be scooped inside the molds for compaction.

2. An empty mold was placed on the plywood support covered with a sheet of saran wrap. The molds were lubricated with vaseline in order to facilitate future removal of the soil from the molds. A second mold was placed on top of the first one to act as a collar to hold the uncompacted soil. A preweighted amount of soil mixture, computed to result in a compacted dry density of 128 $\pm$ 1 pcf at the mixing water content, was dumped into the molds. The loose soil was then levelled by a trowel and a compaction head, 6-inch diameter, was placed on top of the soil and levelled. The entire assembly was then placed on the platform of a Tinius Olson loading machine. The mixture was statically compressed by applying a constant slow loading rate. The compaction head had a circumferenial flange that would rest on the surface of the top mold when the compacted specimen reached the nominal 2-inch thickness. Figure 11 shows a specimen being compacted.
3. After compaction, the specimen was removed and its weight recorded. The difference between the weight of the empty mold and the full mold, gives the weight of the moist compacted sample. Using the moisture content determined from the mixture, the dry weight of soil in the mold was computed. All erosion amounts were computed as percentages of these dry weights.
4. The specimens were then placed in the environmental room (70°F and 50% R.H.) for a period of 7 days, which was sufficient for the specimens to reach constant weights (actually 4 to 5 days were only needed but 7 days was adopted to facilitate working during the conventional work-week). At the end of this 7-day period, the weight of the specimens was recorded, and the specimen was then ready to be sprayed.
5. The same arrangements for spraying given previously for the wind erosion specimens, was used to spray these specimens. The weight of the sprayed specimen was monitored every now and then until the required amount of chemical was sprayed on the surface. For some specimens the required amount was excessive for the specimen

to absorb and flooded the surface, when this happened spraying was stopped when flooding appeared eminent and the actual rate applied was used for reporting of cost of application and was used for future testing when applicable. The dilution ratios, required application rates, and attained application rates are outlined in the chemical summary sheets in Appendix B. The specimens were then placed back in the environmental room to cure.

6. For each chemical treatment, two sets of specimens were prepared. One set was cured for three days and the other for seven days in the environmental room (70°F, 50% R.H.). At the end of the curing period the weight of the specimen was recorded. The specimen was then placed under the traffic erosion-abrasion apparatus at a 60 psi contact pressure and tested for 10 minutes. This 10-minute period was selected since it was sufficient to cause an erosion depth of about 1/2-inch which was about the maximum depth the apparatus can produce before the edges of the frame supporting the rubber rollers started to rest on the surface of the specimen. During the test a small wind blower was directed toward the top of the specimen to remove abraded particles as they separated from the specimen, since their accumulation tended to reduce the abrasive intensity of the apparatus.
7. At the end of the traffic abrasion test the loose particles on the surface of the specimen were removed by the wind blower, and the final specimen's weight was recorded. The difference between this weight and the weight recorded after curing was considered weight lost under traffic abrasion effect. A moisture content sample was taken from the specimen and the amount of weight loss was corrected to a dry weight basis. The ratio of this corrected weight loss to the weight of the dry soil in the compacted specimen in percent was reported as the erosion percent.
8. Duplicate specimens were tested for each test condition, and the resulting average erosion percent was reported as the corresponding value for the particular specimen condition.
9. After hundreds of traffic abrasion tests were made, a correlation between the erosion percent and the depth of erosion was made by

direct measurements. The result of this correlation is given in a graphic form in Figure 12.

Test Results

The results of this traffic abrasion test using the spray-on application are summarized in Table 6, and include the chemical name, the erosion percent under a 60 psi tire pressure for specimens cured for 3 days and 7 days, and the cost of chemical application per square yard. This cost refers to the cost of the chemical only, FOB the location of the manufacturer or supplier. Later on in the report, both chemical costs (FOB supplier and FOB Tucson, Arizona) are reported for selected chemicals. Figure 13 shows a photograph of a control specimen (sprayed with water) after the traffic abrasion test. Figure 14 shows a photograph of a specimen sprayed with chemical No. 18 (Dust Bond) after the traffic abrasion test.

Discussion of Test Results

The results given in Table 6 indicate that several chemicals were quite effective in significantly reducing the erodibility of the treated specimens under the simulated traffic abrasion forces. Chemical treatments resulting in a traffic abrasion loss not exceeding 1/2 percent were considered to be worthy of further testing.

Nineteen chemicals were selected based on their performance in this test to undergo further testing to evaluate the durability of their stabilization potential after being subjected to adverse environmental conditions. These durability tests included freeze-thaw cycles, wet-dry cycles, rain-dry cycles and variation of curing temperatures similar to those discussed for the wind erosion tests. Some details of the environmental durability tests varied from those outlined before, and are discussed below.

Environmental-Durability Tests

For these tests the sprayed specimens were cured for 7 days, subjected to the durability condition specified and then tested in the traffic abrasion simulator at 60 psi tire pressure. Most of the durability tests

TABLE 6: TRAFFIC EROSION RESULTS - SPRAY APPLICATION

Chem. No.	Chemical Name	Erosion Percent; 60 psi		Cost ¢/yd² F.O.B. Supplier
		3-day	7-day	
0	Water	5.35	4.39	----
1a	Soil Stabilizer 801	4.63	0.53	34.8
1b	Soil Stabilizer 801	4.84	0.45	69.6
2	Compound SP-301	Not Recommended by Supplier		
3	White Soil Stabilizer	Not Recommended by Supplier		
4	Stikvel P-65	Not Recommended by Supplier		
5	Velsicol W-617	Not Recommended by Supplier		
6	Redicote E-52	2.78	2.94	4.4
7	Aerospray 70	0.05	0.0	43.2
8a	Aerospray 52	2.51	2.90	49.2
8b	Aerospray 52	2.39	1.81	38.9
9a	Curasol AE	1.49	0.11	24.8
9b	Curasol AE	0.05	0.0	43.3
10	Polyco 2190	Discontinued Supply		
11	Polyco 2460	0.86	0.05	43.5
12	Orzan GL-50	0.05	0.0	3.3
13	Surfaseal	Not Recommended by Supplier		
14	Formula 125	5.33	3.95	32.3
15a	Enzymatic SS-1	5.67	4.01	0.64
15b	Enzymatic SS-1	5.35	3.53	1.28
16a	RTD-SS-X	5.55	4.55	0.80
16b	RTD-SS-X	4.39	4.11	1.60
17	Norlig-41	0.05	0.0	3.2
18a	Dust Bond 100	0.16	0.11	12.0
18b	Dust Bond 100	0.05	0.0	36.0
19	Sodium Silicate #9	1.71	1.20	5.0
20a	Petroset SB	0.82	1.25	25.0
20b	Petroset SB	0.98	0.50	40.0

TABLE 6 - Continued

Chem. No.	Chemical Name	Erosion Percent; 60 psi		Cost ¢/yd^2 F.O.B. Supplier
		3-day	7-day	
21a	Coherex	3.43	2.89	2.9
21b	Coherex	3.27	2.36	5.1
22	Soiltex	0.0	0.11	7.8
23	Thermoset 401	Not Recommended by Supplier		
24a	Enzymatic SS-2	4.1	4.32	Unknown
24b	Enzymatic SS-2	4.52	2.71	Unknown
25	Dresinate DS-60W-80F	1.51	2.10	4.8
26	Paracol 1461	0.85	0.73	19.5
27	Terrakrete #2	0.16	0.21	17.8
28	Terrakrete #1	3.74	3.95	5.3
29	M-Binder	0.0	0.0	18.6
30	Triton X-114-SB	4.54	3.26	9.4
31	Corexit 7740	3.15	5.44	0.20
32	Super Crete 100	1.16	1.06	8.0
33	Aliquat H226	0.11	0.0	11.0
34	Petroset RB	Too Viscous to Spray		
35	Biobinder	2.93	2.34	12.7
36	Surfax 5107	4.0	5.49	0.45
37	Dust Control Oil	0.27	0.53	9.0
38a	Dust Stop	1.22	0.58	6.8
38b	Dust Stop	1.11	0.21	13.0
39	Aquatain (Liquid)	2.75	3.06	35.0
40	Aquatain (Powder)	1.06	1.43	6.3
41a	Foramine 99-194	0.0	0.0	34.0
41b	Foramine 99-194	0.89	0.0	68.0
42	Plyamul 40-153	0.0	0.0	33.0
43	Ashland Oil Stabilizer	0.27	0.22	50.0

TABLE 6 - Concluded

Chem. No.	Chemical Name	Erosion Percent; 60 psi		Cost ¢/yd^2 F.O.B. Supplier
		3-day	7-day	
44	Compound SP-400	Not Recommended by Supplier		
45	Foramine 99-434-2	0.0	0.0	35.0
46	Norlig 41 +F125	0.0	0.05	25.7

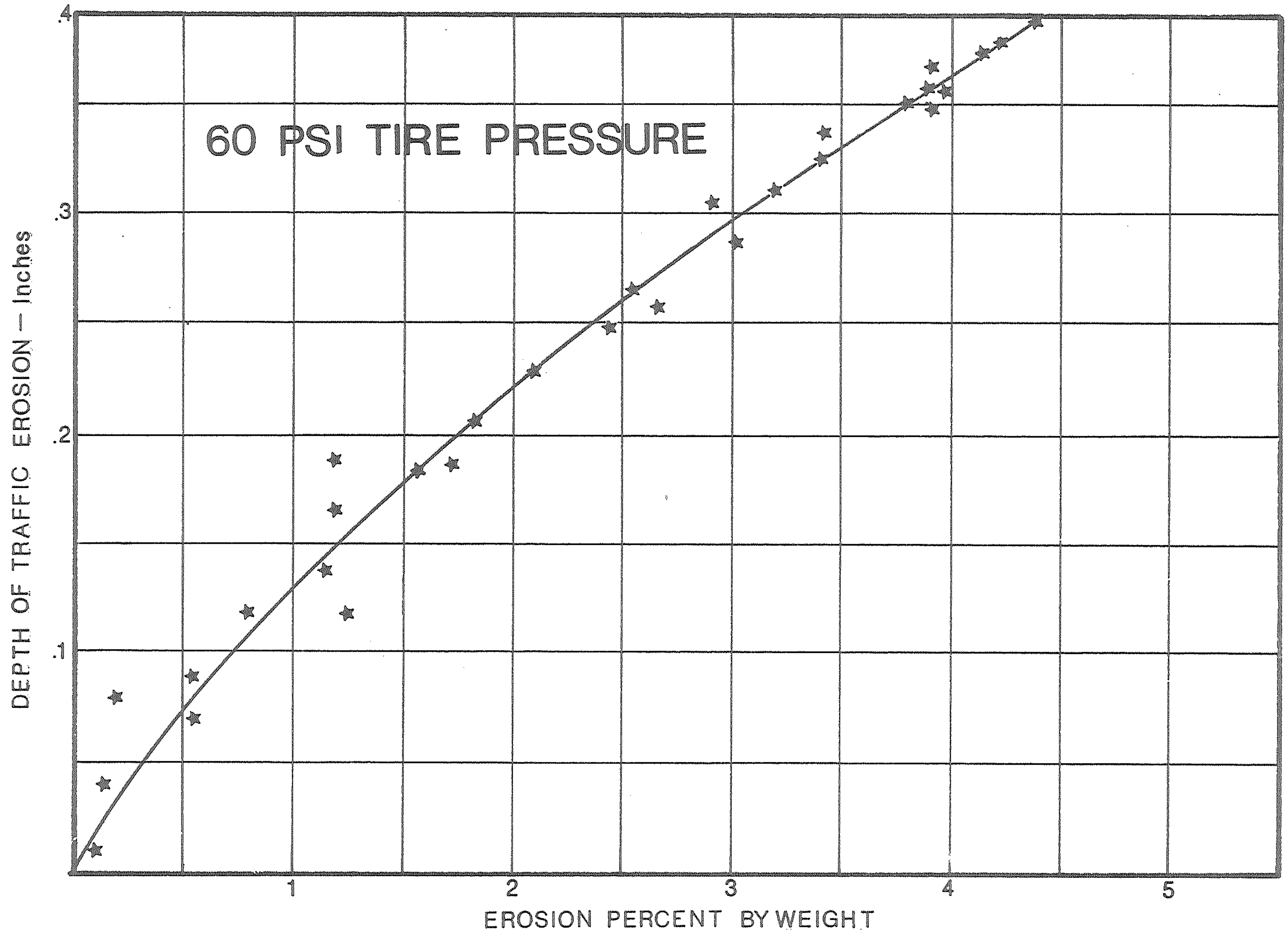

FIGURE 12- CORRELATION BETWEEN DEPTH OF EROSION AND EROSION PERCENT

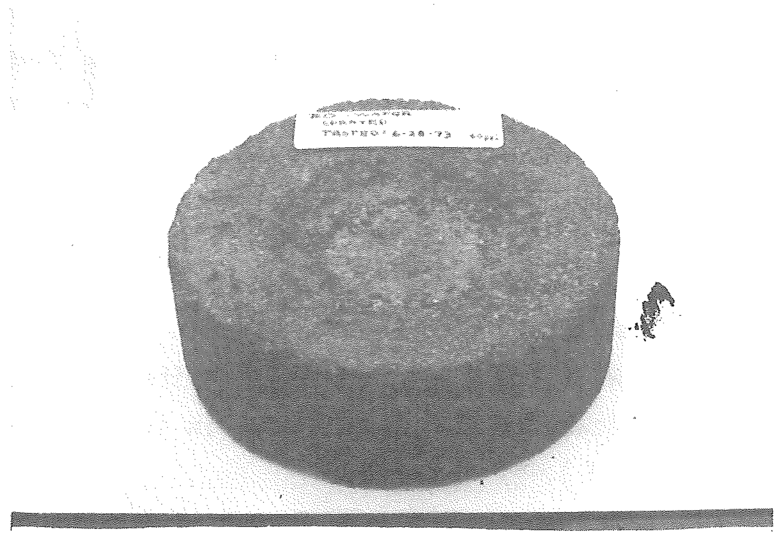

FIGURE 13: TRAFFIC EROSION SPECIMEN (WATER)

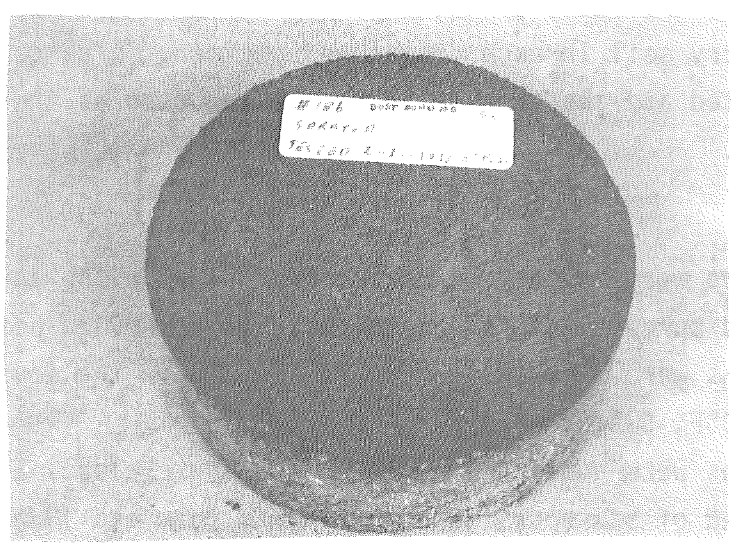

FIGURE 14: TRAFFIC EROSION SPECIMEN (DUST BOND)

caused an increase in the moisture contents of the specimens which would tend to weaken the resistance of the specimens under abrasion forces. Accordingly, the specimens were tested for traffic abrasion immediately at the end of the durability testing without allowing them to dry back, in order that the abrasion test be applied when the specimens were at their weakest conditions.

Freeze-Thaw Cycles

1. Specimens were compacted, cured for 7 days in the environmental room and sprayed with the chemicals as described before.
2. Specimens were allowed to cure for 7 days in the environmental room (70°F, 50% R.H.).
3. Specimens were placed on moist pads for about two hours where water was made accessible to the bottom of the specimens.
4. Specimens were subjected to three freeze-thaw cycles. Each cycle consisted of six hours in a freezing room at 10°F and 18 hours in the environmental room. At the end of the third cycle the weight of each specimen was recorded.
5. Duplicate specimens were tested under 60 psi tire pressure in the traffic abrasion simulator as described before. At the end of the test the weight of the specimen was recorded. For each specimen, the ratio of the corrected weight loss to the weight of the dry soil in each compacted specimen, in percent, was calculated and the average value was reported as the erosion percent.

Wet-Dry Cycles

1. Specimens were compacted, cured for 7 days in the environmental room and sprayed with the chemicals, as described before.
2. Specimens were allowed to cure for 7 days in the environmental room (70°F, 50% R.H.).
3. Specimens were subjected to three wet-dry cycles. Each cycle consisted of six hours in a 70°F humid room and 18 hours in the environmental room. At the end of third cycle the weight of each specimen was recorded.

4. Duplicate specimens were tested under 60 psi tire pressure in the traffic abrasion simulator, as described before. At the end of the test the weight of the specimen was recorded. For each specimen, the ratio of the corrected weight loss to the weight of the dry soil in each compacted specimen in percent was calculated and the average value was reported as the erosion percent.

Rain-Dry Cycles

1. Specimens were compacted, cured for 7 days in the environmental room and sprayed with the chemicals, as described before.
2. Specimens were allowed to cure for 7 days in the environmental room (70°F, 50% R.H.).
3. Specimens were subjected to three rainfall-dry cycles. Each cycle consisted of one hour of rain at 2.38 inches per hour and 23 hours in the environmental room (70°F, 50% R.H.). At the end of the third cycle the weight of each specimen was recorded.
4. Duplicate specimens were tested under 60 psi tire pressure in the traffic abrasion simulator, as described before. At the end of the test the weight of the specimen was recorded. For each specimen, the ratio of the corrected weight loss during the abrasion test to the weight of the dry soil in each compacted specimen in percent was calculated and the average value was reported as the erosion percent due to traffic abrasion. For each specimen, the ratio of the corrected weight loss during the three rain-fall dry cycles to the weight of the dry soil in each compacted specimen in percent was calculated and the average value was reported as the erosion percent due to rainfall. Both values are reported as described later on under "Test Results".

Variation of Curing Temperature

1. Specimens were compacted, cured for 7 days in the environmental room and sprayed with the chemicals, as described before.

2. One group of specimens was allowed to cure for 7 days in a controlled environment of 40°F at 50% R.H. At the end of the curing period the weights of the specimens were recorded.
3. Another identical group of specimens was allowed to cure for 7 days in a closet-size convection oven with temperature ranging between 140°F - 145°F as measured continuously by thermometers. At the end of the curing period the weights of the specimens were recorded.
4. Duplicate specimens from each group were tested under 60 psi tire pressure in the traffic abrasion simulator, as described before. At the end of the test the weights of the specimens were recorded. For each specimen, the ratio of the corrected weight loss to the weight of the dry soil in each compacted specimen in percent was calculated and the average value was reported as the erosion percent.

Test Results

The results of the traffic abrasion tests on the specimens subjected to the various environmental-durability conditions described above, are presented in Table 7. The erosion percent values reported pertain to the corrected soil loss during the traffic abrasion tests. In the rain-dry cycles, both the erosion percent due to traffic abrasion and the erosion percent experienced during the three cycles are reported; the first number refers to the former while the second number refers to the latter, respectively.

Discussion of Test Results

Out of the nineteen chemicals used for this phase of the testing, eight chemicals appeared to effectively endure the various environmental conditions to which they were subjected and afford a good measure or resistance to simulated traffic abrasion under 60 psi tire pressure. The eight chemicals resulted in erosion percent values due to traffic abrasion less than 1/2 of a percent. These chemicals are:

Aerospray 70	Curasole AE
Polycol 2460	Foramine 99-194
Plyamul 40-153	Ashland Oil Stabilizer
Foramine 99-434-2	Norlig 41 + F125

In addition one chemical, Dust Bond 100, resulted in similar effective degrees of control, except at the 40° curing condition.

The results given in Table 7 indicate that both the 40°F. curing condition and the rainfall-dry cycles condition proved to be the most severe type of durability test conditions since they generally resulted in the highest erosion.

When contacted to deliver the necessary chemical quantities for the field application, the suppliers of Polyco 2460, Foramine 99-434-2, and Plyamul 40-153 reported that these chemicals have been discontinued mainly due to lack of availablity of basic ingredients during the energy shortage (January 1974). Due to shortage in chemical supply Ashland Oil Stabilizer was also not available from the manufacturer, in addition the manufacturer of Norlig 41 reported inability to commit any large quantities for delivery in the near future. Incidentally, the Norlig 41 amounts used in the field test for wind erosion was obtained from available stock at the Pima County

TABLE 7: TRAFFIC EROSION AFTER DURABILITY TESTS - SPRAY APPLICATION

Chem. No.	Chemical Name	Erosion Percent, 7-day Cure, 60 psi						Cost ¢/yd^2 F.O.B.	
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	Supplier	Tucson
0	Water	3.12	4.39	2.67	3.87	3.10	4.44-29.6	--	--
1a	Soil Stabilizer 801	4.14	0.53	2.33	4.90	3.05	0.80-27.6	34.8	35.46
7	Aerospray 70	0.05	0.0	0.0	0.0	0.0	0.11-3.7	43.2	47.17
9b	Curasol AE	0.37	0.0	0.0	0.0	0.0	0.16-6.1	43.3	45.8
11	Polyco 2460	0.0	0.05	0.0	0.0	0.05	0.05-2.7	43.5	61.0
12	Orzan GL-50	1.17	0.0	0.27	0.05	2.37	3.11-19.5	3.3	13.6
17	Norlig-41	3.69	0.0	0.0	0.0	0.0	0.64-14.5	3.2	10.56
18b	Dust Bond 100	2.02	0.0	0.0	0.0	0.0	0.32-6.0	36.0	36.0
20b	Petroset SB	1.60	0.50	0.24	0.13	0.91	0.30-1.7	40.0	45.6
22	Soiltex	2.05	0.11	0.0	0.05	0.05	1.12-11.3	7.8	19.5
27	Terrakrete #2	3.80	0.21	0.0	0.05	0.25	1.71-4.71	17.8	19.91
29	M-Binder	2.92	0.0	0.0	0.48	2.16	2.01-2.8	18.6	18.8
33	Aliquat H226	0.48	0.0	0.0	0.05	0.0	3.51-4.5	11.0	12.1
37	Dust Control Oil	0.64	0.53	0.0	0.48	0.21	0.77-0.93	9.0	25.8
38b	Dust Stop	2.08	0.21	0.0	0.0	0.05	1.79-5.6	13.0	16.78
41a	Foramine 99-194	0.45	0.0	0.29	0.50	0.32	0.15-1.3	34.0	50.57

TABLE 7 - Concluded

Chem. No.	Chemical Name	Erosion Percent, 7-day Cure, 60 psi						Cost ¢/yd^2 F.O.B.	
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	Supplier	Tucson
42	Plyamul 40-153	0.0	0.0	0.0	0.0	0.0	0.11-3.5	33.0	40.38
43	Ashalnd Oil Stabilizer	0.50	0.22	0.0	0.0	0.05	0.05-11.0	50.0	77.0
45	Foramine 99-434-2	0.05	0.0	0.0	0.0	0.0	0.0-3.2	35.0	52.0
46	Norlig 41 +F125	0.05	0.05	0.0	0.05	0.05	0.11-1.4	25.7	25.7

Highway Department, in Tucson, Arizona.

Accordingly, only three chemicals out of the eight that proved effective were available for field testing. Due to the availability of Dust Bond 100 (which is also a lignin sulfonate product) in Tucson, and the willingness of the supplier to donate 1000 gallons to the study, it was decided to replace Norlig 41 with Dust Bond 100 in the mixture with F125, as chemical number 46. In addition, due to the observed successful field application of Dust Control Oil, Sultan (1974) and the reasonably good laboratory results shown in Table 7, along with the offer by the manufacturer to donate 2000 gallons for the field testing; this chemical was also added to the chemicals used in the field test.

Chemicals Selected for Road Test - Spray Application

Based on the test results and the discussion given above, five chemicals were used in the road test using the spray on application. Details of the field application and field tests will be given in a later report.

The chemicals used in the field application, in addition to water (control section), are:

Aerospray 70
Dust Bond 100 + F125
Foramine 99-194
Curasole AE
Dust Control Oil

Traffic Erosion Test - Mixing Application

These tests were conducted to evaluate the degree of stabilization imparted by mixing the chemicals with the subgrade material prior to placement and compaction. This application is intended to produce a stabilized road surface for secondary roads that resists the traffic abrasion forces and reduces the dust clouds produced by traffic on unpaved dirt roads. The granitic soil was used exclusively in this traffic erosion-abrasion test. The traffic abrasion simulator discussed previously was also used in this phase of the testing program.

Test Procedure

The same molds used in the previous phases were also used for this test. These were 6-inch diamter and 2-inch high PVC molds. The following steps were followed in performing this test:

1. Granitic soil was oven-dried for about 18 hours and then allowed to cool down to room temperature while covered with a polyethylene sheet. Enough soil for duplicate specimens was mixed in an electric mixer (Blakeslee Mixer) for five minutes with sufficient water that would bring the total moisture content to optimum (9.5 ± 0.5 percent) upon the addition of the recommended amount of chemical solution. The dilution ratios, required application rates, and the cost of application for a compacted 2-inch thick mat, are outlined in the chemical summary sheets in Appendix B. The addition of water first was intended to reduce the surface tension and improve the uniformity of the mixture upon chemical addition. When the chemical solution was added the soil, water and chemical mixture was mixed for an additional 10 minutes in the mixer. After the bowl was removed from the mixer the soil in it was mixed further using a hand scoop for two minutes. A wet towel was placed over the bowl until the soil was ready to be scooped inside the molds for compaction.
2. The specimen preparation and compaction was exactly the same as outlined previously in the traffic abrasion test for specimens prepared by the spray-on application.
3. After compaction, the specimen was removed and its weight recorded. The difference between the weight of the empty mold and the full mold, gives the weight of the moist compacted specimen. Using the moisture content determined from the mixture, the dry weight of soil in the mold was computed. All erosion amounts were computed as percentages of these dry weights.
4. For each chemical treatment, two groups of specimens were prepared. One group was cured for 3 days and the other for 7 days in the environmental room (70°F, 50% R.H.). At the end of the curing period the weight of the specimen was recorded. The specimens were then placed in the traffic abrasion simulator for testing.

5. Each group of specimens consisted of 3 sets (duplicates). One set was tested under 30 psi tire pressure, one under 45 psi tire pressure, and one under 60 psi tire pressure. The traffic abrasion test duration of 10 minutes was used as discussed before.
6. At the end of the traffic abrasion test the loose particles on the surface of the specimen were removed by the wind blower, and the final specimen's weight was recorded. The difference between this weight and the weight recorded after curing was considered weight lost under traffic abrasion effect. A moisture content sample was taken from the specimen and the amount of weight loss was corrected to a dry weight basis. The ratio of this corrected weight loss to the weight of the dry soil in the compacted specimen in percent was reported as the erosion percent.
7. Duplicate specimens were tested for each test condition, and the resulting average erosion percent was reported as the corresponding value for the particular specimen condition. Correlation between erosion percent and depth of eroded surface is given in Figure 12.

Test Results

The results of this traffic abrasion test using the mixing application are summarized in Table 8, and include the chemical name, the erosion percent under 30 psi, 45 psi, and 60 psi tire pressures for specimens cured for 3 days and 7 days, and the cost of the chemical application per square yard for a 2-inch thick mat. This cost refers to the cost of the chemical only, FOB the location of the manufacturer or supplier. Later on in the report, both chemical costs (FOB supplier and FOB Tucson, Arizona) are reported for selected chemicals.

Discussion of Test Results

The results given in Table 8 indicate that only a few chemicals were quite effective in significantly reducing the erodibility of the treated specimens under the simulated traffic abrasion forces. Chemical treatments resulting in a traffic abrasion loss not exceeding 1/2 percent

TABLE 8: TRAFFIC EROSION RESULTS - MIXING APPLICATION

Chem. No.	Chemical Name	Erosion Percent						Cost ¢/yd^2 F.O.B. Supplier 2 in-mat
		3-day Cure, 70°F			7-day Cure, 70°F			
		30 psi	45 psi	60 psi	30 psi	45 psi	60 psi	
0	Water	3.23	4.42	5.61	2.32	3.49	4.41	--
1	Soil Stabilizer 801	2.06	3.0	3.89	2.73	3.05	4.43	34.8
2	Compound SP-301	Not Recommended by Supplier						
3	White Soil Stabilizer	Not Recommended by Supplier						
4	Stikvel P-65	Not Recommended by Supplier						
5	Velsicol W-617	Not Recommended by Supplier						
6a	Redicote E-52	0.91	1.28	1.99	0.54	0.96	1.74	21.1
6b	Redicote E-52	0.21	0.84	1.32	0.32	0.63	0.79	29.7
6c	Redicote E-52	0.10	0.10	0.36	0.10	0.16	0.10	42.2
7a	Aerospray 70	1.75	1.86	3.65	1.86	1.96	5.90	45.4
7b	Aerospray 70	1.97	2.23	4.51	2.08	3.02	4.83	34.0
8a	Aerospray 52	3.78	4.76	5.97	2.83	3.68	5.14	51.8
8b	Aerospray 52	3.62	4.53	4.74	2.93	4.09	6.44	38.9
9a	Curasol AE	1.96	2.76	4.22	2.49	3.13	4.70	24.8
9b	Curasol AE	2.22	3.17	4.79	2.59	2.91	3.73	43.3
10	Polyco 2190	Discontinued by Supplier						

TABLE 8 - Continued

Chem. No.	Chemical Name	Erosion Percent						Cost ¢/yd^2 F.O.B. Supplier 2 in-mat
		3-day Cure, 70°F			7-day Cure, 70°F			
		30 psi	45 psi	60 psi	30 psi	45 psi	60 psi	
11a	Polyco 2460	1.43	1.65	1.80	0.80	1.59	2.02	43.5
11b	Polyco 2460	1.85	2.27	2.72	1.26	1.47	1.79	65.2
12a	Orzan GL-50	0.05	0.59	0.74	0.05	0.25	0.64	3.3
12b	Orzan GL-50	0.05	0.10	0.21	0.0	0.05	0.11	5.0
13	Surfaseal	Not Recommended by Supplier						
14	Formula-125	2.52	2.79	3.49	2.95	3.11	3.46	32.3
15a	Enzymatic SS-1	3.66	4.18	5.19	2.92	3.55	5.78	1.8
15b	Enzymatic SS-1	2.28	2.69	3.70	1.80	3.18	3.98	3.6
16a	RTD-SS-X	1.59	2.91	4.47	1.27	1.59	4.05	1.8
16b	RTD-SS-X	1.97	2.18	4.97	1.44	2.34	3.31	3.6
17a	Norlig-41	0.0	0.0	0.11	0.0	0.0	0.11	3.2
17b	Norlig-41	0.0	0.0	0.0	0.0	0.0	0.0	4.4
18	Dust Bond 100	0.0	0.0	0.36	0.0	0.0	0.21	36.0
19a	Sodium Silicate #9	4.82	5.12	6.09	3.37	3.85	6.51	10.0
19b	Sodium Silicate #9	4.43	5.28	6.95	4.45	6.20	7.67	11.0
20	Petroset SB	0.74	1.53	4.14	0.52	1.31	3.02	25.0

TABLE 8 - Continued

Chem. No.	Chemical Name	Erosion Percent						Cost‡ ¢/yd² F.O.B. Supplier 2 in-mat
		3-day Cure, 70°F			7-day Cure, 70°F			
		30 psi	45 psi	60 psi	30 psi	45 psi	60 psi	
21a	Coherex	1.58	2.12	3.84	1.11	2.58	3.18	9.2
21b	Coherex	0.63	1.99	2.36	1.47	2.15	3.49	10.1
22a	Soiltex	0.0	0.05	0.16	0.0	0.0	0.0	10.0
22b	Soiltex	0.05	0.11	0.11	0.0	0.0	0.0	11.0
23	Thermoset 401	2.50	3.29	4.71	1.65	3.46	4.56	34.0
24a	Enzymatic SS-2	2.44	2.65	3.41	1.16	2.87	3.73	Unknown
24b	Enzymatic SS-2	1.91	2.29	5.56	1.81	3.52	4.10	Unknown
25	Dresinate DS-60W-80F	3.41	3.94	5.53	2.58	2.90	4.0	18.7
26	Paracol 1461	1.21	1.42	2.05	0.95	1.05	1.26	19.5
27	Terrakrete #2	1.90	2.80	3.59	0.58	1.49	2.41	24.4
28	Terrakrete #1	3.24	3.61	3.80	1.38	2.23	2.94	6.6
29a	M-Binder	0.69	2.43	3.16	0.69	2.28	3.84	18.6
29b	M-Binder	0.58	1.85	3.28	0.64	0.96	1.85	28.0
30	Triton X-114 SB	2.87	3.50	6.67	0.90	2.98	4.16	12.9
31	Corexit 7740	1.32	2.48	3.86	1.43	2.01	3.54	0.2
32	Super Crete-100	2.16	2.76	3.65	3.12	3.55	5.01	8.0

TABLE 8 - Concluded

Chem. No.	Chemical Name	Erosion Percent						Cost‡ ¢/yd² F.O.B. Supplier 2 in-mat
		3-day Cure, 70°F			7-day Cure, 70°F			
		30 psi	45 psi	60 psi	30 psi	45 psi	60 psi	
33	Aliquat H226	1.88	2.98	4.58	2.15	3.78	5.22	22.0
34	Petroset RB	Solidified in Container						
35a	Biobinder	1.48	2.85	4.40	2.20	2.61	3.84	17.0
35b	Biobinder	1.74	2.43	2.89	2.42	3.27	4.60	34.0
36	Surfax 5107	1.90	2.80	3.12	1.80	3.91	4.60	0.5
37a	Dust Control Oil	0.36	2.07	3.69	0.62	1.31	2.72	15.0
37b	Dust Control Oil	0.0	1.23	2.35	0.21	0.31	1.31	7.5
38a	Dust Stop	0.42	1.85	2.69	0.69	1.53	2.38	10.5
38b	Dust Stop	1.11	1.80	2.11	0.25	1.21	2.22	20.0
39	Aquatain (Liquid)	0.91	1.11	2.07	0.16	1.22	2.44	35.0
40	Aquatain (Powder)	1.54	2.29	2.98	1.38	2.29	2.83	21.0
41	Foramine 99-194	1.06	2.90	4.22	0.98	2.78	3.59	34.0
42	Plyamul 40-153	1.31	2.27	2.80	1.43	1.69	3.17	33.0
43	Ashland Oil Stabilizer	0.0	0.05	0.10	0.05	0.05	0.10	37.0
44	Compound SP-400	Not Recommended by Supplier						
45	Foramine 99-434-2	1.99	2.35	2.86	1.77	2.66	2.92	35.0
46	Norlig +F125	0.10	0.14	0.16	0.0	0.05	0.05	25.7

were considered to be worthy of further testing.

Only seven chemicals were selected based on their performance in this test to undergo further testing to evaluate the durability of their stabilization potential after being subjected to adverse environmental conditions. These chemicals are:

Redicote E-52	Orzan GL-50
Norlig - 41	Dust Bond 100
Soiltex	Ashland Oil Stabilizer

Norlig-41 +F125

It is interesting to note that five out of these seven chemicals have lignin sulfonate as a base material. Foramine 99-194 was also added for further testing since the chemical used in the above test was very viscous since it was stored at temperatures exceeding 80°F for a long period, that may have affected its stabilization potential. A new batch of Foramine 99-194 was delivered to investigate this effect.

The environmental-durability tests included freeze-thaw cycles, wet-dry cycles, rainfall-dry cycles, and variation of curing temperatures. Details of the durability tests are discussed below.

Environmental-Durability Tests

For these tests the mixed and compacted specimens were cured for 7 days, subjected to the durability conditions specified, and then tested in the traffic abrasion simulator at 30 psi, 45 psi, and 60 psi tire pressures. Most of the durability tests caused an increase in the moisture contents of the specimens which would tend to weaken the resistance of the specimens under abrasion forces. Accordingly, the specimens were tested for traffic abrasion immediately at the end of the durability testing without allowing them to dry back in order that the abrasion test be applied when the specimens were at their weakest conditions.

Freeze-Thaw Cycles

1. Specimens were compacted and cured for 7 days in the environmental room, as described before.

2. Specimens were placed on moist pads for about 2 hours where water was made accessible to the bottom of the specimens.
3. Specimens were subjected to 3 freeze-thaw cycles. Each cycle consisted of 6 hours in a freezing room at 10°F and 18 hours in the environmental room. At the end of the third cycle the weight of each specimen was recorded.
4. Every group of specimens consisted of 3 sets (duplicates). One set was tested under 30 psi tire pressure, one set under 45 psi tire pressure and one set under 60 psi tire pressure. The traffic abrasion test duration of 10 minutes was used as described previously.
5. At the end of the abrasion test, the weight of the specimen was recorded. For each specimen, the ratio of the corrected weight loss to the weight of the dry soil in each compacted specimen, in percent, was calculated and the average value (duplicates) was reported as the erosion percent.

<u>Wet-Dry Cycles</u>

1. Specimens were compacted and cured for 7 days in the environmental room, as described brfore.
2. Specimens were subjected to 3 wet-dry cycles. Each cycle consisted of 6 hours in a 70°F humid room and 18 hours in the environmental room. At the end of the third cycle the weight of each specimen was recorded.
3. Every group of specimens consisted of 3 sets (duplicates). One set was tested under 30 psi tire pressure, one set under 45 psi tire pressure, and one set under 60 psi tire pressure. The traffic abrasion test duration of 10 minutes was used as described previously.
4. At the end of the abrasion test, the weight of the specimen was recorded. For each specimen, the ratio of the corrected weight loss to the weight of the dry soil in each compacted specimen, in percent, was calculated and the average value (duplicates) was reported as the erosion percent.

Rain-Dry Cycles

1. Specimens were compacted and cured for 7 days in the environmental room, as described before.
2. Specimens were subjected to 3 rainfall-dry cycles. Each cycle consisted of 1 hour of rain at 2.38 inches per hour and 23 hours in the environmental room (70°F, 50% R.H.). At the end of the third cycle the weight of each specimen was recorded.
3. Every group of specimens consisted of 3 sets (duplicates). One set was tested under 30 psi tire pressure, one set under 45 psi tire pressure, and one set under 60 psi tire pressure. The traffic abrasion test duration of 10 minutes was used as described previously.
4. At the end of the abrasion test, the weight of the specimen was recorded. For each specimen, the ratio of the corrected weight loss during the abrasion test to the weight of the dry soil in each compacted specimen in percent was calculated, and the average value (duplicates) was reported as the erosion percent due to traffic abrasion. For each specimen, the ratio of the corrected weight loss during the 3 rainfall-dry cycles to the weight of the dry soil in each compacted specimen, in percent, was calculated and the average value (duplicates) was reported as the erosion percent due to rainfall. Both values are reported as described later on under "Test Results".

Variation of Curing Temperatures

1. Specimens were prepared and compacted as described before.
2. One group of specimens was allowed to cure for 7 days in a controlled environment of 40°F at 50% R.H. At the end of the curing period the weights of the specimens were recorded.
3. Another identical group of specimens was allowed to cure for 7 days in a closet-size convection oven with temperature ranging between 140°F-145°F as measured continuously by thermometers. At the end of the curing period the weights of the specimens were recorded.
4. Every group of specimens consisted of 3 sets (duplicates).

One set was tested under 30 psi tire pressure, one set under 45 psi tire pressure, and one set under 60 psi tire pressure. The traffic abrasion test duration of 10 minutes was used as described previously.

5. At the end of the abrasion test, the weight of the specimen was recorded. For each specimen, the ratio of the corrected weight loss to the weight of the dry soil in each compacted specimen, in percent, was calculated and the average value (duplicates) was reported as the erosion percent.

Test Results

The results of the traffic abrasion tests on the mixed specimens subjected to the various environmental-durability conditions described above, are presented in Table 9. The erosion percent values reported pertain to the corrected soil loss during the traffic abrasion tests. In the rain-dry cycles, both the erosion percent due to traffic abrasion and the erosion percent experienced during the 3 cycles are reported; the first number refers to the former while the second number refers to the latter, respectively.

Discussion of Test Results

Under 30 psi simulated tire pressure, four chemicals, out of the eight tested, appeared to effectively endure the various environmental conditions to which they were subjected and afford a good measure of traffic abrasion loss, less than 1/2 percent. These chemicals are:

Redicote E-52	Dust Bond 100
Ashland Oil Stabilizer	Norlig 41 +F125

Similar effectiveness, exclusive of traffic abrasion after the rain-dry cycles was given by Norlig-41 and Soiltex.

Under 45 psi simulated tire-pressure, Redicote E-52 and Norlig 41 +F125 were effective after all durability conditions. Except after rain-dry cycles the same degree of effectiveness was given by Norlig-41, Dust Bond 100 and Soiltex.

TABLE 9: TRAFFIC EROSION AFTER DURABILITY TESTS - MIXING APPLICATION

Chem. No.	Chemical Name	Erosion Percent, 7-day Cure, 30 psi						Cost, 2 in-mat ¢/yd^2 F.O.B.	
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	Supplier	Tucson
0	Water	2.88	2.32	1.72	2.63	3.02	3.62-23.4	--	--
6c	Redicote E-52	0.36	0.10	0.0	0.0	0.15	0.12-2.3	42.2	42.2
12b	Orzan GL-50	0.64	0.0	0.10	0.0	0.11	1.16-19.5	5.0	20.6
17b	Norlig-41	0.34	0.0	0.0	0.05	0.14	1.42-14.5	4.4	14.52
18	Dust Bond 100	0.11	0.0	0.0	0.0	0.08	0.43-11.5	36.0	36.0
22a	Soiltex	0.26	0.0	0.0	0.0	0.16	0.92-12.5	10.0	25.0
41	Foramine 99-194	2.06	0.98	1.65	2.97	3.14	4.83-6.2	34.0	50.57
43	Ashland Oil Stabilizer	0.15	0.05	0.17	0.49	0.05	0.47-4.5	37.0	57.0
46	Norlig 41 +F125	0.05	0.0	0.0	0.05	0.05	0.16-2.3	25.7	25.7

TABLE 9 - Continued

Chem. No.	Chemical Name	Erosion Percent, 7-day Cure, 45 psi						Cost, 2 in-mat ¢/yd^2 F.O.B.	
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	Supplier	Tucson
0	Water	3.32	3.49	2.91	3.35	3.61	4.02-22.3	---	---
6c	Redicote E-52	0.50	0.16	0.12	0.10	0.18	0.20-1.9	42.2	42.2
12b	Orzan GL-50	1.25	0.05	0.16	0.0	0.16	1.48-21.2	5.0	20.6
17b	Norlig-41	0.38	0.0	0.0	0.05	0.14	1.58-13.8	4.4	14.52
18	Dust Bond 100	0.16	0.0	0.0	0.05	0.12	0.61-9.9	36.0	36.0
22a	Soiltex	0.32	0.0	0.0	0.0	0.22	1.53-13.7	10.0	25.0
41	Foramine 99-194	3.92	2.78	2.15	4.09	3.60	5.32-7.8	34.0	50.57
43	Ashland Oil Stabilizer	0.25	0.05	0.20	0.71	0.07	0.69-3.2	37.0	57.0
46	Norlig 41 +F125	0.12	0.05	0.0	0.10	0.08	0.21-2.5	25.7	25.7

TABLE 9 - Concluded

Chem. No.	Chemical Name	Erosion Percent, 7-day Cure, 60 psi						Cost, 2 in-mat ¢/yd^2 F.O.B.	
		40°F	70°F	140°F	Fr-Th	Wet-Dry	Rain-Dry	Supplier	Tucson
0	Water	4.61	4.41	3.87	4.31	4.83	5.42-21.4	---	---
6c	Redicote E-52	0.92	0.10	0.33	0.10	0.22	0.28-2.1	42.2	42.2
12b	Orzan GL-50	1.27	0.11	0.21	0.0	0.21	2.3-20.3	5.0	20.6
17b	Norlig-41	0.40	0.0	0.0	0.05	0.18	2.02-11.2	4.4	14.52
18	Dust Bond 100	0.18	0.21	0.06	0.0	0.18	0.86-10.3	36.0	36.0
22a	Soiltex	0.42	0.0	0.13	0.11	0.42	1.78-12.2	10.0	25.0
41	Foramine 99-194	4.95	3.59	2.40	4.98	5.24	5.68-8.1	34.0	50.57
43	Ashland Oil Stabilizer	0.50	0.10	0.24	0.77	0.13	1.00-3.8	37.0	57.0
46	Norlig 41 +F125	0.21	0.05	0.07	0.31	0.28	0.41-2.9	25.7	25.7

Under 60 psi simulated tire pressure, only Norlig-41 +F125 was effective after all durability conditions. Similar degree of effectiveness was given by Redicote E-52, Norlig-41, Dust Bond 100, Soiltex and Ashland Oil Stabilizer with the exception of maybe after one or two of the durability conditions imposed.

It is again interesting to note that the lignin sulfonate base chemicals performed outstandingly in the traffic abrasion tests of the mixed specimens. Also that we were successful in waterproofing (reducing solubility) of the Norlig-41 treatment with the addition of Formula 125.

Selection of Chemicals for Road Test - Mixed Application

Since it did not seem realistic or necessary to use three or four different lignin-based chemicals in the field application, it was sought to use Norlig-41 to represent this group of chemicals. However, as mentioned previously, the manufacturer of Norlig-41 indicated inability to commit any large quantities for delivery in the near future. At the same time the supplier of Dust Bond 100 (also a lignin-based chemical) indicated willingness to supply any needed amount to Tucson along with a donation of 1,000 gallons. Accordingly, Redicote E-52 and a mixture of Dust Bond 100 plus F 125 were recommended for field application. At this time the supplier of Dust Control Oil indicated his willingness to donate 2,000 gallons of the chemical for the spray-on and mixed-in field application. Therefore, the field application included the Redicote E-52 (supplier donated 4,500 gallons), Dust Bond 100 + F 125, and Dust Control Oil.

Details of the field application and field tests will be given in a later report.

CHAPTER 4

SUMMARY AND CONCLUSIONS

Summary

1. The specific aims of this study were to identify those chemical stabilizing agents that are best capable of controlling soil erosion due to wind and traffic forces and providing positive dust control measures. The stabilizers' criteria for inclusion were that they be economical, easy to apply in the field, and durable to withstand various environmental conditions.
2. Forty-six commerically available chemicals were tested in this study. Laboratory testing included subjecting specimens of a dune sand, treated with spray-on chemicals, to simulated wind velocities up to 90 mph. Specimens of compacted granitic subgrade soil, treated with either a spray-on or a mixed-in application of the chemicals, were subjected to simulated traffic abrasive forces under simulated tire pressures up to 60 psi.
3. Selected chemical treatments were subjected to various environmental-durability conditions before testing. Durability conditions included freeze-thaw cycles, wet-dry cycles, rainfall-dry cycles, and various curing temperatures.
4. Based upon the results of this laboratory testing phase, several chemical stabilizers were selected for application in a large scale field test.

Conclusions

1. After being subjected to the various durability tests and then tested under wind velocities up to 90 mph, several spray-on applied chemicals afforded less than 5% erosion-loss to the dune sand. These chemicals were:

Aerospray 70	Surfaseal
Petroset SB	Coherex
Dresinate DS-60W-80F	Paracol 1461
Terrakrete #2	Dust Stop
Aquatain (Powder)	Foramine 99-194
Plyamul 40-153	Polyco 2460
Foramine 99-434-2	Norlig 41 +F125

In addition, Aerospray 52, Curasol AE, and Orzan GL-50, exhibited almost similar performance. The cost of chemical treatment for the chemicals outlined above ranges between less than 2 cents up to 9 cents per square yard. This cost is for chemical only and based on cost FOB suppliers or manufacturers.

2. After being subjected to various durability tests and then tested under traffic abrasion of simulated tire pressures up to 60 psi, several spray-on applied chemicals afforded less than 1/2 percent erosion loss to the granitic soil. These chemicals were:

Aerospray 70	Curasol AE
Polyco 2460	Foramine 99-194
Plyamul 40-153	Ashland Oil Stabilizer
Foramine 99-434-2	Norlig 41 +F125

In addition Dust Bond 100 resulted in similar effectiveness except when cured at 40°F.

The cost of the chemical application (chemical only, FOB manufacturers) for the chemicals outlined above, ranged between 26 cents and 50 cents per squard yard.

3. After being subjected to various durability tests and then testing under traffic abrasion of simulated tire pressures up to 60 psi, few mixed-in chemicals afforded less than 1/2 percent erosion loss to the granitic soil. These chemicals were:

Redicote E-52	Dust Bond 100
Ashland Oil Stabilizer	Norlig 41 +F125

In addition, similar effectiveness, except after being subjected to rain-dry cycles, was given by Norlig-41, and Soiltex.

The cost of chemical treatment for a 2-inch mat (chemical only, FOB manufacturers) for the chemicals outlined above, ranged between less than 5 cents up to 42 cents, per square yard.

4. It is pointed out that several lignin-base products were quite effective in reducing wind and traffic erosion at reasonable costs. In particular these products proved superiority when mixed with the soil and under traffic abrasion simulation. However, due to their susceptibility to leach out under water effects, these products did not perform as well under rain-dry conditions.
5. In order to reduce solubility of lignin-base materials Norlig-41 was selected to be mixed with a solution Formula-125 (a sodium methyl Siliconate base material) which is commercially used as a waterproofer. The results indicated that the mixture is capable of passing effectively all the tests performed in this study. The addition of Formula-125 appears to have significantly reduced the solubility of the lignin in water. It appears that mixing F 125 with any other lignin products would have given similar results.
6. It is pointed out that all chemical applications were made in keeping with a certain cost limit per square yard. Some chemicals may have given better performance at a different rate of application.
7. In analysing the laboratory data in this study certain tolerable erosion-losses were imposed as limiting values. These values were based on comparative results, erosion losses of untreated (control) specimens, along with past experience of the principal investigator.

   It is hoped that based on the results of the field application, more definitive correlations maybe drawn between actual field conditions and laboratory erosion losses, which still is lacking in the state-of-the-art.

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APPENDIX A

CHEMICAL SOLICITATIONS

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF ENGINEERING
ENGINEERING EXPERIMENT STATION

16 December 1972

Gentlemen:

On 6 December 1972 the Engineering Experiment Station through the College of Engineering at the University of Arizona entered into a contractual agreement with the Arizona Highway Department to study measures for soil erosion and dust control using chemical stabilizers. The specific aims of the study are to search for, determine, and identify those stabilizing agents that are best capable of controlling soil erosion due to wind and traffic factors and providing positive dust control measures. These selected stabilizers shall be economical, easy to apply in the field, and durable to withstand various environmental conditions.

By this letter, we are seeking the aid of your organization, and we extend to you the opportunity to furnish chemical stabilizers and/or other additives which may lead to the successful accomplishment of our goals. All chemicals furnished for these studies should conform to the enclosed criteria for selection of stabilizers. Enclosed also are the type of data required for all the stabilizers to be furnished and the type of testing to be conducted on the chemically treated soils during our study program.

Any aid you may be able to give us will be greatly appreciated. We would appreciate receiving as soon as possible, free of charge, samples of any materials you would like us to include in our program. A sample should be of sufficient quantity to stabilize five (5) cubic feet of soil.

Yours very truly,

H. A. Sultan

H. A. Sultan, Ph.D.
Professor of Civil Engineering and
Principal Investigator

HAS:GC

Enclosure

I. CRITERIA FOR SELECTION OF STABILIZERS

As applied, the solicited stabilizers shall be products that are non-toxic, non-flammable, non-corrosive to allow easy storage, are easy to handle and apply, and unharmful to plant or animal life should they leach out of the treated soil. The products should be economical to use with a material cost limit not exceeding 15 cents per square yard for stabilization of non-trafficable areas such as embankments and open spaces. Material cost shall not exceed 75 cents per square yard for stabilization of trafficable unpaved roads. These are the initial stabilization costs, with annual maintenance costs not exceeding 5 cents and 10 cents per square yard for non-trafficable and trafficable areas, respectively.

II. TYPE OF DATA REQUIRED FOR THE CHEMICALS

(1) Name of material and any available brochures.

(2) Major constituents, as many as you can.

(3) Cost per gallon and/or per pound, as delivered.

(4) Concentration (dilution) recommended for application.

(5) Rate of application recommended for use; please indicate whether rate is for concentrate or solution.

III. TESTS TO BE CONDUCTED INCLUDE

(1) Wind erosion of sprayed sand dunes.

(2) Traffic erosion of mixed and/or sprayed subgrade soil.

(3) Same as in (1) and (2), after freeze-thaw cycles.

(4) Same as in (1) and (2), after rainfall-drying cycles.

(5) Field program for the best stabilizers based on the laboratory studies will be conducted around October, 1973.

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING AND
ENGINEERING MECHANICS

Gentlemen:

We are currently conducting a research program under contractual agreement with the Arizona Highway Department and the Federal Highway Administration, to study measures for soil erosion and dust control using chemical stabilizers. The specific aims of the study are to search for, determine, and identify those stabilizing agents that are best capable of controlling soil erosion due to wind and traffic factors and providing positive dust control measures. These selected stabilizers shall be economical, easy to apply in the field, and durable to withstand various environmental conditions.

Earlier in the year, we solicited your cooperation to participate in this research project with any chemical stabilizers that you feel may prove pertinent to this endeavor. However, since we have not received any answer to our request, we hope that you would kindly contact us as soon as possible regarding whether you would like to submit any of your chemicals to be included in our program.

All chemicals furnished for these studies should conform to the enclosed criteria for selection of stabilizers. Enclosed also are the type of data required for all the stabilizers to be furnished and the type of testing to be conducted on the chemically treated soils during our study program.

Any aid you may be able to give us will be greatly appreciated. We would appreciate receiving as soon as possible, free of charge, samples of any materials you would like us to include in our program. A sample should be of sufficient quantity to stabilize five (5) cubic feet of soil.

Yours very truly,

H. A. Sultan

H. A. Sultan, Ph.D.
Professor of Civil Engineering and
Principal Investigator

HAS:ps

Enclosure

TABLE A-1 - LIST OF CHEMICAL SUPPLIERS CONTACTED

Abacus Polymer, Incorporated
8030 N. Monticello Avenue
Skokie, Illinois 60076

Adhesive Engineering Company
1411 Industrial Road
San Carlos, California 94070

Adhesive Products Corporation
1660 Boone Avenue
Bronx, New York 10460

Alco Chemical Corporation
Trenton Avenue & William Street
Philadelphia, Pennsylvania 19134

Allied Chemical
P.O. Box 365
Morristown, New Jersey 07960

American Can Company
Chemical Products Department
American Lane
Greenwich, Connecticut 06830

American Cyanamid Company
South Cheery Street
Wallingford, Connecticut 06492

American Cyanamid Company
Wayne, New Jersey 07470
Attention: Engineering Chemicals Dept.

American Hoechst Corp.
11312 Hartland Street
North Hollywood, California 91605

American Metaseal Corporation
509 Washington Avenue
Carlstadt, New Jersey 07072

American Petro Chemical Corp.
3134 California Street, N.E.
Minneapolis, Minnesota 55418

Table A-1 Continued

Amercoat Corporation
201 North Berry Street
Brea, California 92621

Amoco Chemicals Corporation
3201 South Michigan Avenue
Chicago, Illinois 60616

Applied Plastics Company, Inc.
130 Penn Street
El Segundo, California 90245

Archer Daniels Midland Company
10701 Lyndale Avenue, South
P.O. Box 532
Minneapolis, Minnesota 55440

Armak Company
8401 West 47th St.
McCook, Illinois 60525

Armstrong Products Company, Inc.
Argonne Road
Warsaw, Indiana 46580

Arthur C. Trask Co.
327 So. LaSalle Street
Chicago, Illinois 60604

Ashland Chemical Company
P.O. Box 1503
Houston, Texas 77001

Ashland Oil Inc.
Ashland, Kentucky 41101

Atlas Minerals and Chemicals
Mertztown, Pennsylvania 19539

BASF Wyandotle Corporation
Wyandotle, Michigan 48192

Borden Chemical Company
511 Lancaster Street
Leominster, Massachusetts 01453

Borg-Warner
Marbon Chemical Division
P.O. Box 68
Washington, West Virginia 26181

Table A-1 Continued

Cabot Corp.
125 High Street
Boston, Massachusetts 02110

Richard Carlyon
751 N. Edwards Dr.
Carson City, Nevada 89701

Carter-Waters Corp.
Chem. Prod. Department
2440 Pennway
Kansas City, Missouri 64108

The Ceilcote Company
140 Sheldon Road
Berea (Cleveland), Ohio 44017

Celanese Resins
11th at Hill Street
P.O. Box 8248
Louisville, Kentucky 40209

Chemical Development Corp.
Endicott Street
Danvers, Massachusetts 01923

Chemical Processing Services
Div. of Middlesex Plastics, Inc.
Raritan, New Jersey 08869

Chevron Chemical Company
Oronite Division
200 Bush
San Francisco, California 94104

CIBA Products Corporation
556 Morris Avenue
Summit, New Jersey 07901

CIBA-Geigy Corporation
Ardsley, New York

Claremont Polychemical Corporation
39 Powerhouse Road
Roslyn Heights, New York 11517

Consolidated Soils, Inc.
13790 43rd., North
St. Petersburg, Florida 33732

Table A-1, Continued

Crown Zellerback
Chemical Product Division
1400 North Harbor Blvd.
Fullerton, California 92635

DeSoto Chemical Coatings, Inc.
1700 South Mt. Prospect Road
Des Plaines, Illinois 60018

Dow Corning Corp.
Midland, Michigan 48640

Dow Chemical Company
Plastic Materials & Products
Dept.
Midland, Michigan 48640

E.I. Dupont de Nemour and Co.
Plastics Department
Dupont Building
10th and Market
Wilmington, Delaware 19898

Dust Bond of Arizona
4222 N. 39th Ave.
Phoenix, Arizona 85019

Eastman Chemical Products, Inc.
Chemicals Division B-75
Kingsport, Tennessee 37662

Edoco Technical Products, Inc.
22039 South Westward Avenue
Long Beach, California 90810

The Electric Storage Battery Company
Atlas Mineral Products Division
Mertztown, Pennsylvania 19539

Empire Petroleum Co.
P.O. Box 9006
Denver, Colorado 80909

Enjay Chemical Company
8230 Stedman Street
Houston, Texas 77029

Enzymatic Products Incorporated
3138 North 28th Avenue
Phoenix, Arizona 85016

Table A-1 Continued

Epoxylite Corporation
Box 3397
South El Monte, California 91733

Esso Research and Engineering Co.
P.O. Box 8
Linden, New Jersey 07036

Exxon Chemical Co.
8230 Stedman St.
Houston, Texas 77029

Finestone Adhesines Co.
15800 Tireman Ave.
Detroit, Michigan 48228

Firestone Plastics Company
Chemicals Division
P.O. Box 699
Pottstown, Pennsylvania 19464

The Flintkote Company
P.O. Box 157
Whippany, New Jersey 07981

The Flintkote Company
Industrail Products Department
480 Central Avenue
East Rutherford, New Jersey 07073

Foremost Foods Co.
111 Pine Street
San Francisco, California 94111

H. B. Fuller Company
255 Eagle Street
St. Paul, Minnesota 55102

Furane Plastics, Inc.
4516 Brazil Street
Los Angeles, California 90039

General Adhesives and Chemical Co.
P.O. Box 90
Nashville, Tennessee 37202

General Electric Company
Silicone Products Dept.
Waterford, New York 12188

Table A-1 Continued

General Latex and Chemical Corp.
666 Main Street
Cambridge, Massachusetts 02139

General Latex and Chemical (Canada) Limited
68 Eastern Avenue, East
Brampton, Ontario, Canada

General Mills, Inc.
Chemical Division
South Kensington Road
Kankakee, Illinois 60901

The Glidden Company
900 Union Commerce Building
Cleveland, Ohio 44115

B. F. Goodrich Chemical Company
6100 Oak Tree Blvd.
Cleveland, Ohio 44131

Goodyear Tire and Rubber Company
Akron, Ohio 44316

W. R. Grace and Company
Construction Products Division
62 Whitlemore Ave.
Cambridge, Massachusetts 02140

Groutech Services
1680 Bryant Street
Daly City, California 94015

Jack Hatton
5275 Craner Ave.
No. Hollywood, California 91601

Hardman Inc.
600 Cortland Street
Belleville, New Jersey 07109

Henley and Co., Inc.
202 East 44th St.
New York, New York 10017

Hercules Powder Company, Inc.
Wilmington, Delaware 19899

Table A-1 Continued

Hercules Incorporated
One Maritime Plaza
San Francisco, California 94111

High Temp Resins, Inc.
225 Greenwich Avenue
Stamford, Connecticut 06902

E. F. Houghton and Co.
303 W. Lehigh Ave.
Philadelphia, Pennsylvania 19133

Hughson Chemical Company
Division Lord Corporation
1635 West 12th
Erie, Pennsylvania 16512

Humble Oil and Refining Co.
P.O. Box 2180
Houston, Texas 77001
Attn: Mr. R. C. Granberry
Production Manager
Southeastern Region

Hysol Corporation
Franklin Street
Olean, New York 14760

"Insuro" Chemical Company, Inc.
Box 208
Worcester, Massachusetts 01601

International Epoxy Corporation
P.O. Box 23069
Ft. Lauderdale, Florida 33307

International Latex and Chemical Corp.
Tylac Chemicals Division
P.O. Drawer K
Dover, Delaware 19901

Isochem
Cook Street
Lincoln, Rhode Island 02865

Tom James
12740 Matteson Ave.
Los Angeles, California 90066

Table A-1 Continued

Jameson Chemical Company
205 West Wacker Drive
Chicago, Illinois 60606

Johnson March Corp.
3018 Market Street
Philadelphia, Pennsylvania 19104

Kaiser Chemicals
2901 East Fourth Ave.
P.O. Box 19097
Columbus, Ohio 43219

Don Keller
1440 S. Allec St.
Anaheim, California 92805

John Kennedy
7554 Clybourn Ave.
Sun Valley, California

Mr. Eugene S. Koehler
Resins and Chemicals Marketing
Dow Corning Corporation
Midland, Michigan 48640

Koppers Company, Inc.
440 College Park Drive
Monroeville, Pennsylvania 15146

Robert Korf
6311 Rutland Ave.
Riverside, California 92503

Larutan Corporation
1440 S. Allec Street
Anaheim, California 92805

Magnolia Plastics, Inc.
5547 Peachtree Industrial Blvd.
Chamblee, Georgia 30005

Macklin 3, Inc.
3528 West Sahuaro Drive
Phoenix, Arizona 85029

Master Builders
2490 Lee Blvd.
Cleveland Heights, Ohio 44118

Table A-1 Continued

Patrick McCullough
P.O. Box 2111
Santa Fe Springs, California 90670

McNeil Brothers, Inc.
Box 204 - Devon Station
Milford, Connecticut 06460

Metachem Resins Corp.
Mereco Products Division
5305 Willington Ave.
Cranston, Rhode Island 02901

Minnesota Mining and Manufacturing
Scotch Ply Reinforcing Plastics
Division
1208 University Avenue
St. Paul, Minnesota 55104

Mobay Chemical Company
Penn Lincoln Parkway West
Pittsburgh, Pennsylvania 15205

Monsanto Polymers and Petrochemicals
190 Grochmal Avenue
Indian Orchard, Massachusetts 01051

Morton Chemical Company
11710 Lake Avenue
Woodstock, Illinois 60098

National Lead Co.
900 West 18th Street
Chicago, Illinois 60607

National Poly Chemicals, Inc.
Eames Street
Wilmington, Massachusetts 01887

National Starch and Chemical Corp.
1700 West Front Street
Plainfield, New Jersey 07063

OHM Research Products Inc.
4222 N. 39th Ave.
Phoenix, Arizona 85019

Pacific Lumber Co.
100 Bush Street
San Francisco, California 94104

Table A-1 Continued

Parker Chemicals, Inc.
P.O. Box 3506
Odessa, Texas 79760

Pecoff Brothers Nursery
Route 5 Box 215R
Escondido, California 92025

Pennwalt Corporation
Lucidol Chemical Division
P.O. Box 1048
Buffalo, New York 14240

Permagile Corporation of America
101 Commercial Street
Plainview, New York 11803

Permalastic Products Company
15800 Tireman
Detroit, Michigan 48228

Permatex Company, Inc.
P.O. Box 1350
West Palm Beach, Florida 33402

Philadelphia Quartz Co.
Public Ledger Building
Independence Square
Philadelphia, Pennsylvania 19106

Phillips Petroleum Company
Chemical Department
Commercial Development Division
15 Cl Phillips Building
Bartlesville, Oklahoma 74003

Pittsburg Chemical Company
Pittsburgh, Pennsylvania 15219

Pittsburgh Plate Glass Company
742 Grayson Street
Berkely, California 94710

Plas-Chem Corporation
6177 Maple Avenue
St. Louis, Missouri 63130

Pozament Corporation
Box 146 - Devon Station
Milford, Connecticut 06462

Table A-1 Continued

Products Research Company
2919 Empire Avenue
Burbank, California 91504

Protex Industries, Inc.
Special Coating Division
1331 West Evans Avenue
Denver, Colorado 80223

Quaker Oats Company
John Stuart Research Laboratories
617 West Main Street
Barrington, Illinois 60010

Reichhold Chemicals, Inc.
120 South Linden Ave.
South San Francisco, California 94080

Reichhold Chemicals, Inc.
2340 Taylor Way
Tacoma, Washington 98401

Ren Plastics, Inc.
5656 South Cedar Street
Lousing, Michigan 48908

Research and Development Laboratory
4420 N. Highway Dr.
Tucson, Arizona 85704

The Rinchem Co., Inc.
1550 W. Lower Buckeye
Phoenix, Arizona 85007

Robeson Process Co.
P.O. Box 960
Eric, Pennsylvania 16512

Rohm and Haas Company
Independence Mall West
Philadelphia, Pennsylvania 19105

Rubber Latex Company of America
Delwanna Avenue
Clifton, New Jersey 07014

Rynne International Corp.
30 East 60th Street
New York, New York 10022

Table A-1 Continued

Sahuaro Petroleum and Asphalt Company
P.O. Box 6536
Phoenix, Arizona 85005

Semco Laboratory
2745 W. Chemy Lynn Rd.
Phoenix, Arizona 85017

Shell Chemical Company
110 N. 51st Street
New York City, New York 10014

Shell Chemical Company
9901 Paramount Blvd.
Downey, California 90240

Shell Development Company
Emeryville, California 94608

Shell Oil Company
Products Application Dept.
10 South Riverside Plaza
Chicago, Illinois 60606

Shell Oil Company
Two Shell Plaza
P.O. Box 2105
Houston, Texas 77001

Sika Chemical Corporation
875 Valley Brook Ave.
Lyndhurst, New Jersey 07071

Silmar Chemical Corp.
12335 South Van Ness Avenue
Hawthorne, California 90250

Sinclair-Koppers Company
Department TR
Koppers Building
Pittsburgh, Pennsylvania 15219

Sinclair Research, Inc.
400 East Sibley Blvd.
Harvey, Illinois 60426

Soil Control Products
12034 Centralia Road
Artesia, California 90701

Table A-1 Continued

Soil Seal Corp.
6311 Rutland Ave.
Riverside, California 92503

Sta-Soil Corp.
5275 Craner Avenue
North Hollywood, California 91601

Walt Stanley
946 E. Tunnell St.
Santa Maria, California 93454

Stauffer Chemical Company
Plastics Division
382 Madison Avenue
New York, New York 10017

Steelcote Manufacturing Co.
3418 Gratiot Street
St. Louis, Missouri 63103

Super Crete Inc.
2249 S. McQueen
Mesa, Arizona 85202

Swift and Company
Chemicals for Industry
115 West Jackson Blvd.
Chicago, Illinois 60604

Tenneco Chemicals
20 N. Wacker
Chicago, Illinois 60606

Thermoset Plastics, Inc.
5101 East 65th Street
Indianapolis, Indiana 46220

Thiokol Chemical Division
930 Lower Ferry Road
P.O. Box 1296
Trenton, New Jersey 08607

Gene Thouvenell
P.O. Box 283
Upland, California 91786

Sterling Tracy
1001 Glendale Blvd.
Los Angeles, California 90026

Table A-1 Continued

Tucson Soil Chemicals
P.O. Box 4561
Tucson, Arizona 85717

Union Carbide Corporation
Adhesive, Sealant and
Electronic Intermedialis
P.O. Box 670
Bound Brook, New Jersey 08805

Uniroyal Chemicals
Division of Uniroyal, Inc.
Bethany, Connecticut 06525

The Upjohn Company
CPR Division
555 Alaska Avenue
Torrance, California 90503

Velsicol Chemical Corporation
341 East Ohio Street
Chicago, Illinois 60611

Mr. Veril Wade
Bestline Products
P.O. Box 2142
El Cajon, California 92021

Vitra Seal Company
P.O. Box 122
East Rutherford, New Jersey 07073

Wallace and Tiernan, Inc.
Lucidol Division
1740 Military Road
Buffalo, New York 14240

West Chemical Products, Inc.
42 - 16 West Street
Long Island City, New York 11101

White Chemical Co.
1310 West Watkins St.
Phoenix, Arizona 85007
Attn: Mr. Phil Burgh

George W. Whitesides Company
31st and Michigan Avenue
Louisville, Kentucky 40212

Table A-1 Continued

Witco Chemical Company, Inc.
Golden Bear Division
P.O. Box 378
Bakersfield, California 93302

Zel Chemical Co.
14945 S.W. 72nd Ave.
Portland, Oregon 97223

APPENDIX B

SUMMARY SHEETS FOR CHEMICALS USED

No. 0

Name: Water (Control Specimens)

Manufacturer: Supplied from tap

Chemical Constituents: H_2O

Properties: Color: Colorless, transparent

Smell: None

Wt/gal: 8.33 lbs./gallon

Sp. gravity: 1.0

pH: 7.0

Cost: -

Recommended Use (Screening):

i) Wind Erosion:

a) Apply at 1 gsy

Comments: Natural color, no cracks, 2 in. penetration

ii) Traffic Erosion (Spray):

a) Apply at 1 gsy

iii) Traffic Erosion (Mixing):

a) Enough water to reach optimum water content

No. 1

Name: Soil Stabilizer 801

Manufacturer: Chemische Werke Huels

Supplier: Henley and Company
202 East 44th St.
New York, New York 10017

Chemical Constituents: An aliphatic, partly cured polymer which achieves final cure upon exposure to oxygen

Properties: Color: Dark brown liquid, becomes white when mixed with water

Smell: Strong odor

wt/gal: 8.3 lbs/gallon

Sp. Gravity: 0.99 (at 50% dilution with water)

pH: 5.2 @ 26C

Cost: $1.05/lb F.O.B. East or Gulf Coast

Recommended Use (Screening):

i) Wind Erosion:

a) Use 50 gms/yd^7 of the 50% active solution with enough water to reach optimum = 11.6¢/yd^2

Comments: Natural color, nominal crust, no cracks, 2-inch penetration
Suggested for wind erosion only
Supplied at 50% active solution

ii) Traffic Erosion (Spray) Not suggested by supplier

a) Use 150 gms of 50% active solution/yd^2 with enough water to reach optimum = 34.8¢/yd^2

b) Use 300 gms/yd^2 of 50% active solution with enough water to reach optimum = 69.6¢/yd^2

iii) Traffic Erosion (Mixing) Not suggested by supplier

a) Use 150 gms of 50% active solution with enough water to reach optimum = 34.8¢/yd^2

No. 2

Name: Compound Sp. 301

Manufacturer: The Johnson-March Corporation
3018 Market St.
Philadelphia, Pennsylvania 19104

Chemical Constituents: Latex Copolymer Emulsion

Properties: Color: No color - color indicator is available

Smell: Strong odor

Wt/gal: 8.3 lbs/ gallon

Sp. Gravity: 1.0

pH: 6.6 @ 26 C

Cost: $1.15/ gallon F.O.B. Philadelphia, Pa.

Recommended Use: (Screening)

i) Wind Erosion

a) Apply as delivered at 1 gal/100 ft^2 = 10.4¢/yd^2

Comments: Natural color, nominal crust, 1/16 - 1/8 inch penetration
Suggested for wind erosion only

No. 3

Name: White Soil Stabilizer

Manufacturer: White Chemical Co.
1310 W. Watkins St.
Phoenix, Arizona 85007

Chemical Constituents: A laytex polymer

Properties: Color: Milky white

Smell: Strong odor

Wt/gal: 9 lbs/gal

Sp. Gravity: 1.08

pH: 5.9 @ 26 C

Cost: $4.31/ gallon F.O.B. Phoenix, Arizona

Récommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:20 with water (chem:water)

b) Apply at 1/2 gsy = 10.3¢/yd^2

Comments: Natural color, nominal crust, no cracks, 1/8-inch penetration

Suggested for wind erosion only

Chemical is biodegradable

No. 4

Name: Stikvel P. 65

Manufacturer: Velsicol Chemical Corporation
341 East Ohio St.
Chicago, Illinois 60611

Chemical Constituents: It is an emulsion of a hydrocarbon resin, dispersed in water

Properties: Color: Cream, opaque

Smell:

Wt/gal: 8.45 lbs/gallon @ 77^{o} F.

Sp. Gravity: 1.02 @ 60^{o} F.

pH: 8.0 ± 1.0

Cost: $1.53/gallon (18¢/lb) F.O.B. Marshall, Illinois

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:1 with water
Apply at 1/5 gsy = 15¢/yd^2

Comments: Light brown color, nominal crust, some cracks, 1/16 3/16 inch penetration

Suggested for wind erosion only

No. 5

Name: Velsicol W-617

Manufacturer: Velsicol Chemical Corporation
341 East Ohio St.
Chicago, Illinois 60611

Chemical Constituents: An anionic emulsion of a hydrocarbon thermoplastic resin

Properties: Color: White, cream

Smell: No odor

Wt/gal: 8.35 lbs/gallon

Sp. Gravity: .98 - 1.00

pH: 8.5 - 9.5

Cost: $1.17/gallon

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:1 with water

Apply at 1/4 gsy = 14.6¢/yd^2

Comments: Light brown color, nominal crust, some cracks, 1/8 inch penetration

Suggested for wind erosion only

No. 6

Name: Redicote E-52

Manufacturer: Armak Company

Supplier: Arizona Refining Company
P.O. Box 1453
Phoenix, Arizona

Chemical Constituents: A cationic CSS-1h asphalt emulsion

Properties: Color: Dark brown

Smell: Slight odor

Wt/gal: 8.33 lbs/gallon

Sp. Gravity: 1.0

pH: 5.5

Cost: $0.22/gallon F.O.B. Phoenix, Arizona

Reommended Use: (Screening)

i) Wind Erosion (Not recommended by manufacturer)

a) Dilute at 1:1 with water
Apply at 1 gsy = 11¢/yd^2

ii) Traffic Erosion (Spray) (Not recommended by manufacturer)

a) Dilute at 1:1 with water
Apply at 1 gsy = 11.0¢/yd^2 (0.4 gsy attained = 4.4¢/yd^2)

iii) Traffic Erosion (Mixing) - Prewet soil with water near optimum

a)	4.2% emulsion	By dry weight of soil at 127 pcf	21.1¢/yd^2
b)	5.9% emulsion		29.7¢/yd^2
c)	8.4% emulsion		42.2¢/yd^2

Comments: When sprayed for wind erosion: Black thick coating, sticky, no cracks (1/16 - 1/8 inch penetration)
Suggested for traffic-mixing only

No. 7

Name: Aerospray 70

Manufacturer: American Cyanamid Company
Wayne, New Jersey 07470

Chemical Constituents: It is a polyvinyl acetate resin, containing 60 = 1% total solids by weight

Properties: Color: Milky-white

Smell: No odor

Wt/gal: 9.25 lbs/gallon @ 20° C.

Sp. Gravity: 1.11

pH: 4.6 @ 25° C.

Cost: $2.50/gallon F.O.B. Torrence, California

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:10 with water
Apply at 1/2 gsy = 11.4¢/yd^2

Reduced Rate:
Dilute at 1:20 with water
Apply at 1/2 gsy = 5.95¢/yd^2

Comment: Natural color, nominal crust, no cracks, 7/16 - 1.0 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:lo with water
Apply at 2 gsy = 45.4¢/yd^2 (1.9 gsy attained = 43.2¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:10 with water
Apply at 2 gsy = 45.4¢/yd^2

b) Apply same dilution at 1.5 gsy = 34¢/yd^2

No. 8

Name: Aerospray 52

Manufacturer: American Cyanamid Company
Wayne, New Jersey 07470

Chemical Constituents: It is an alkyd emulsion, containing 48 ± 1% total solids by weight

Properties: Color: Milk-white, viscous liquid

Smell: No odor

Wt/gal: 8.8 lbs/gallon @ 20° C.

Sp. Gravity: 1.05

pH: 8 - 9 @ 25° C.

Cost: $2.85/gallon F.O.B. Torrence, California

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:10 with water
Apply at 1/2 gsy = 13¢/yd^2

Reduced Rate:
Dilute at 1:20 with water
Apply at 1/2 gsy = 6.8¢/yd^2

Comments: Natural color, nominal crust, no cracks, 1/8 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:10 with water
Apply at 2 gsy = 51.8¢/yd^2 (1.9 gsy attained = 49.2¢/yd^2)

b) Apply same solution at 1.5 gsy = 38.9¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:10 with water
Apply at 2 gsy = 51.8¢/yd^2

b) Apply same solution at 1.5 gsy = 38.9¢/yd^2

No. 9

Name: Curasol AE

Manufacturer: American Hoechst Corporation
11312 Hartland St.
North Hollywood, California 91605

Chemical Constituents: Polymer Dispersion

Properties: Color: White, milky liquid

Smell: Strong odor

Wt/gal: 8.8 lbs./gallon

Sp. Gravity: 1.05

pH: 4.5 @ 25^{o} C

Cost: \$2.60/gallon F.O.B. Los Angeles, California

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:20 with water
Apply at 1 gsy = 12.4¢/yd^2

Reduced Rate
Apply same solution at 1/2 gsy = 6.2¢/yd^2

Comments: Natural color, hard crust, no cracks, 1/2 - 1.0 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:10 with water
Apply at 1 gsy = 24.8¢/yd^2

b) Dilute at 1:5 with water
Apply at 1 gsy = 43.3¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:10 with water

b) Dilute at 1:5 with water
Apply at 1 gsy = 43.3¢/yd^2

No. 10

Name: Polyco 2190

Manufacturer: Borden Chemical
511 Lancaster St.
Leominster, Mass. 01453

Chemical Constituents: Vinyl Acrylic, polyvinyl acetate copolymer

Properties: Color: Milky white

Smell: Strong odor

Wt/gal: 8.75 lbs/gallon

Sp. Gravity: 1.05

pH: 4.5 @ 25^{o} C.

Cost: $1.75/gallon 920¢/lb) F.O.B. Leominster, Mass.

Recommender Use: (Screening)

i) Wind Erosion

a) Dilute at 1:1 with water
Apply at 1/6 gsy = 14.5¢/yd^2

b) Dilute at 1:5 with water
Apply at 1/2 gsy = 14.5¢/yd^2

ii) Traffic Erosion (Spray)

a) Dilute at 1:2 with water
Apply at 1 gsy = 58.3¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:2 with water
Apply at 1 gsy = 58.3¢/yd^2

b) Apply same solution at 0.6 gsy = 35¢/yd^2

Comments: When sprayed for wind erosion, brown color, hard thick crust, no cracks, 3/4 - 1 inch penetration

*Chemical was discontinued by manufacturer after first wind testing was completed.

No. 11

Name: Polyco 2460

Manufacturer: Borden Chemical
511 Lancaster St.
Leominster, Mass. 01453

Chemical Constituents: GRS styrene/butadiene latex

Properties: Color: Milky white

Smell: No odor

Wt/gal: 8.7 lbs/gallon

Sp. Gravity: 1.04

pH: 10 - 11

Cost: \$0.87/gallon (10¢/lb) F.O.B. Leominster, Mass.

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:1 with water
Apply at 1/3 gsy = 14.5¢/yd^2

b) Dilute at 1:5 with water
Apply at 1 gsy = 14.5¢/yd^2

Reduced Rate:
Dilute at 1:14 with water
Apply at 1 gsy = 5.8¢/yd^2

Comments: Natural color, hard thick crust, no cracks, 3/4 - 1 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:1 with water
Apply at 1 gsy = 43.5¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:1 with water
Apply at 1 gsy = 43.5¢/yd^2

b) Use undiluted at 3/4 gal/yd^2 = 65.2¢/yd^2

No. 12

Name: Orzan GL-50

Manufacturer: Crown Zellerbach
Suite 621
1400 N. Harbor Blvd.
Fullerton, Calif. 92632

Chemical Constituents: Solution of chemicals and lignin sulfonates

Properties: Color: Dark brown

Smell: Strong odor

Wt/gal: 10.2 lbs/gallon

Sp. Gravity: 1.22

pH: 4 @ a solution of 25%

Cost: $0.10/gallon F.O.B. Lebanon, Oregon

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:2 with water
Apply at 1 gsy = 3.3¢/yd^2

Reduced Rate:
Dilute at 1:5 with water
Apply at 1 gsy = 1.7¢/yd^2

Comment: Brown color, thich, hard crust, no cracks, 3/16 - 3/4 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:2 with water
Apply at 1 gsy = 3.3¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:2 with water
Apply at 1 gsy = 3.3¢/yd^2

b) Dilute at 1:1 with water
Apply at 1 gsy = 5¢/yd^2

No. 13

Name: Surfaseal

Manufacturer: Groutech Services
1680 Bryant St.
Daly City, California 94015

Chemical Constituents: Not given by manufacturer

Properties: Color: Milky white

Smell: Slight odor

Wt/gal: 9.2 lbs/gallon

Sp. Gravity: .98

pH: 4.4 @ 20^{o} C.

Cost: $4.00/gallon F.O.B. Daly City, California

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:9 with water
Apply at 1/3 gsy = 13.3¢/yd^2

Reduced Rate:

Dilute at 1:20 with water
Apply at 1/3 gsy = 6.3¢/yd^2

Comments: Natural color, hard crust, no cracks, 1/8 - 1/4 inch penetration
Suggested for wind erosion only by manufacturer

No. 14

Name: Formula 125

Manufacturer: Transcontinental Research and Development
3410 E. Pennsylvania
Tucson, Arizona

Chemical Constituents: Sodium Methyl Siliconate

Properties: Color: Clear

Smell: No odor

Wt/gal: 8.4 lbs/gallon

Sp. Gravity: 1.00

pH: 11.4 @ 26^{o} C.

Cost: $10.00/gallon F.O.B. Tucson, Arizona

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:30 with water
Apply at 1/3 gsy = 10.8¢/yd^2

b) Dilute at 1:40 with water
Apply at 1/2 gsy = 12.2¢/yd^2

Comments: Natural color, loose, soft, no crust

ii) Traffic Erosion (Spray)

a) Dilute at 1:30 with water
Apply at 1 gsy = 32.3¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:30 with water
Apply at 1 gsy = 32.3¢/yd^2

No. 15

Name: Enzymatic S.S.-1

Manufacturer: Enzymatic Products, Inc.
3138 N. 28th Ave.
Phoenix, Arizona

Chemical Constituents: A biological material

Properties: Color: Dark brown

Smell: Strong odor

Wt/gal: 8.38 lbs/gallon

Sp. Gravity: 1.0

pH: 4.2 @ 25^{o} C.

Cost: $4.00/gallon F.O.B. Phoenix, Arizona

Recommended Use: (Screening)

ii) Traffic Erosion (Spray)

a) Dilute at 1:500 with water
Apply at 0.8 gsy = 0.64¢/yd^2

b) Dilute at 1:250 with water
Apply at 0.8 gsy = 1.28¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:500 with water
Apply at optimum (2.2 gsy) = 1.76¢/yd^2

b) Dilute at 1:250 with water
Apply at optimum (2.2 gsy) = 3.52¢/yd^2

Comments: Suggested for traffic erosion only

No. 16

Name: RTD-SS-X

Manufacturer: Semco
2929 E. Thomas
Suite 204
Phoenix, Arizona 85016

Chemical Constituents: A biological material

Properties: Color: Clear

Smell: Strong odor

Wt/gal: 8.62 lbs/gallon

Sp. Gravity: 1.03

pH: 7.3 @ 27^{o} C.

Cost: $4.00/gallon F.O.B. Phoenix, Arizona

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:500 with water
Apply at 1 gsy = 0.8¢/yd^2

b) Dilute at 1:250 with water
Apply at 1 gsy = 1.6¢/yd^2

Comments: Natural color, nominal crust, no cracks

ii) Traffic Erosion (Spray)

a) Dilute at 1:500 with water
Apply at 1 gsy = 0.8¢/yd^2

b) Dilute at 1:250 with water
Apply at 1 gsy = 1.6¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:500 with water
Apply at optimum (2.2 gsy) = 1.76¢/yd^2

b) Dilute at 1:250 with water
Apply at optimum (2.2 gsy) = 3.52¢/yd^2

No. 17

Name: Norling-41 (58 L)

Manufacturer: American Can Company
American Lane
Greenwich, Connecticut 06830

Chemical Constituents: Solution of chemicals and lignin-sulfonate

Properties: Color: Dark brown

Smell: Strong odor

Wt/gal: 11.1 lbs/gallon

Sp. Gravity: 1.33

pH: 3.9 @ 25^{o} C.

Cost: $0.08/gallon F.O.B. Rothschild, Wisconsin

Recommended Use (Screening):

i) Wind Erosion

a) Dilute at 1.1 with water
Apply at 1 gsy = 4¢/yd^2

Reduced rate:
Dilute at 1:4 with water
Apply at 1 gsy = 1.6¢/yd^2

Comments: Brown color with black tone, hard crust, no cracks, 1/4 - 5/8 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:3 with water
Apply at 1.6 gsy = 3.2¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:3 with water
Apply at 1.6 gsy = 3.2¢/yd^2

b) Dilute at 1:3 with water
Apply at optimum (2.2 gsy) = 4.4¢/yd^2

No. 18

Name: Dust Bond - 100

Manufacturer: OHM Research Products, Inc.
4222 N. 39th Ave.
Phoenix, Arizona 85019

Chemical Constituents: A mixture of lignin sulfonate and other chemicals

Properties: Color: Dark brown

Smell: No odor

Wt/gal: 9.31 lbs/gallon

Sp. Gravity: 1.12

pH: 4.7 @ 26^{o} C.

Cost: \$0.36/gallon F.O.B. Phoenix, or Tucson, Arizona

Recommended Use: (Screening)

i) Wind Erosion

a) Use as is, no dilution

Apply at 1/3 gal/yd^2 = 12¢/yd^2

Reduced Rate:

Use as is, no dilution

Apply at 1/6 gsy = 6¢/yd^2

Comments: Dark brown color, hard crust, some cracks, 1/4 inch penetration

ii) Traffic Erosion (Spray)

a) Use at no dilution

Apply at 1/3 gsy = 12¢/yd^2

b) Use at no dilution

Apply at 1 gsy = 36¢/yd^2

iii) Traffic Erosion (Mixing)

a) Use at no dilution

Apply at 1 gsy = 36¢/yd^2

No. 19

Name: Sodium Silicate Grade #9

Manufacturer: E. I. Dupont de Nemours and Company
Technical Services Laboratory
Chestnut Run
Wilmington, Delaware 19899

Chemical Constituents: Sodium Silicate

Properties: Color: Clear

Smell: No odor

Wt/gal: 11.7 lbs/gallon

Sp. Gravity: 1.4

pH: Alkaline

Cost: $0.25/gallon F.O.B. Pineville, Louisiana

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:4 with water

Apply at 1 gsy = 5.0¢/yd^2

Reduced Rates:

Dilute at 1:9 with water

Apply at 1 gsy = 2.5¢/yd^2

Comments: Natural color, hard crust, no cracks, 1/2-3/4 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:4 with water

Apply at 2 gsy = 10.0¢/yd^2 (1.0 gsy attained = 5.0¢/yd^2)

iii) Traffic Erosion (Mixing)

a) Dilute at 1:4 with water

Apply at 2 gsy = 10.0¢/yd^2

b) Apply same solution at optimum (2.2 gsy) = 11.0¢/yd^2

No. 20

Name: Petroset SB

Manufacturer: Phillips Petroleum Company
Batlesville, Oklahoma 74004

Chemical Constituents: A butadiene-styrene rubber and resin tacifier in an oil-water emulsion

Properties: Color: Light tan
Smell: No odor
Wt/gal: 8.4 lbs/gallon
Sp. Gravity: 1.04 ± .03
pH: 6 ± 0.5

Cost: $1.50/gallon F.O.B. Borger, Texas

Recommended Use: (Screening)

i) Wind Erosion
- a) Dilute at 1:12 with water
  Apply at 1 gsy = 11.5¢/yd^2
- b) Dilute at 1:7 with water
  Apply at 3/4 gsy = 14¢/yd^2

Reduced Rate:
Dilute at 1:25 with water
Apply at 1 gsy = 5.8¢/yd^2

Comments: Natural crust, hard, no cracks, 3/8 - 1/2 inch penetration

ii) Traffic Erosion (Spray)
- a) Dilute at 1:5 with water
  Apply at 1 gsy = 25¢/yd^2
- b) Apply same solution at 2 gsy = 50¢/yd^2 (1.6 gsy attained = 40¢/yd^2

iii) Traffic Erosion (Mixing)
- a) Dilute at 1:5 with water
  Apply at 1 gsy = 25¢/yd^2

No. 21

Name: Coherex

Manufacturer: Witco Chemical

Supplier: General Control Co.
3334 E. Pennsylvania
Tucson, Arizona 85714

Chemical Constituents: Semi-liquid natural petroleum resin wetting solution

Properties: Color: Light yellow

Smell: Slight odor

Wt/gal: 8.4 lbs/gallon

Sp. Gravity: 1.02

pH: 7.1 @ 26^{o} C.

Cost: $0.23/gallon F.O.B. Bakersfield, California

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:7 with water
Apply at 1 gsy = 2.9¢/yd^2
Same as reduced rate

b) Dilute at 1:4 with water
Apply at 1 gsy = 4.6¢/yd^2

c) Dilute at 1:4 with water
Apply at 1:5 gsy = 6.9¢/yd^2

d) Apply 1:7 solution a 1 gsy, then a day later apply 1:4 at 1 gsy = 7.5¢/yd^2

Comment: Brown color, nominal cost, wet and soft, no cracks, 3/16 - 1 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:7 with water
Apply at 2 gsy = 5.8¢/yd^2 (1.0 gsy attained = 2.9¢/yd^2)

b) Dilute at 1:4 with water
Apply at 2 gsy = 9.2¢/yd^2 (1.1 gsy attained = 5.1¢/yd^2)

iii) Traffic Erosion (Mixing)

a) Dilute at 1:4 with water
Apply at 2 gsy = 9.2¢/yd^2

b) Apply same solution at optimum (2.2 gsy) = 10.1¢/yd^2

No. 22

Name: Soiltex

Manufacturer: Protex Industries, Inc.
1331 W. Evans Ave.
Denver, Colorado 80223

Chemical Constituents: Lignin sulfonate and other chemical mixture

Properties: Color: Dark brown

Smell: Strong odor

Wt/gal: 10.4 lbs/gallon

Sp. Gravity: 1.24

pH: 6 @ 25^{o} C.

Cost: \$0.20/gallon F.O.B. Denver, Colorado (Assumed)

\$0.5/gallon F.O.B. Tucson, Arizona (Given)

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:3 with water

Apply at 1 gsy = 5.0¢/yd^2

Reduced Rate:

Dilute at 1:9 with water

Apply at 1 gsy = 2.0¢/yd^2

Comments: Black-brown color, hard crust, no cracks, 5/8 - 1-1/4 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:3 with water

Apply at 2 gsy = 10.0/yd^2 (1.6 gsy attained) = 7.8¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:3 with water

Apply at 2 gsy = 10.0¢/yd^2

b) Use same solution at optimum (2.2 gsy) = 11.0¢/yd^2

No. 23

Name: Thermoset 401

Manufacturer: Thermoset Plastics, Inc.
5101 E. 65th St.
Indianapolis, Indiana 46220

Chemical Constituents: An epoxy resin and epoxy hardener

Properties: Color: Neutral

Smell: Resinous

Wt/gal: 9 lbs/gallon

Sp. Gravity: 1.08

pH: 3.5 @ 26^{o} C.

Cost: 1200 lbs resin + 400 lbs hardner = $1,672 F.O.B. Indianapolis, Indiana

Recommended Use: (Screening)

iii) Traffic Erosion (Mixing)

a) Use 111 gm (Resin 401) +37 gm (hardner 401) — 34¢/yd^2

Comments: Suggested for traffic-mixing only.

No. 24

Name: Enzymatic S.S. - 2

Manufacturer: Semco Laboratory
2745 W. Cherry Lynn Rd.
Phoenix, Arizona 85017

Chemical Constituents: A biological material

Properties: Color: Dark yellow

Smell: Strong odor

Wt/gal: 8.38 lbs/gallon

Sp. Gravity: 1.0

pH: 8.4 @ 26^{o} C.

Cost: Not given

Recommended Use: (Screening)

ii) Traffic Erosion (Spray)

a) Dilute at 1:2000 with water
Apply at 1 gsy

b) Dilute at 1:1500 with water
Apply at 1 gsy

iii) Traffic Erosion (Mixing)

a) Dilute at 1:2000 with water
Apply at optimum (2.2 gsy)

b) Dilute at 1:1500 with water
Apply at optimum (2.2 gsy)

Comments: Suggested for traffic erosion only.

No. 25

Name: Dresinate DS-60W-80F

Manufacturer: Hercules Incorporated
One Maritime Plaza
San Francisco, California 94111

Chemical Constituents: Dispersion of thermoplastic resin and viscosity reducer

Properties: Color: Dark brown

Smell: No odor

Wt/gal: 8.56 lbs/gallon

Sp. Gravity: 1.02

pH: 10.8 @ 25^{o} C.

Cost: $0.34/gallon F.O.B. Portland, Oregon

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:3 with water

Apply at 1 gsy = 8.5¢/yd^2

Reduced Rate:

Dilute at 1:9 with water

Apply at 1 gsy = 3.4¢/yd^2

Comments: Black, brown, color, nominal soft crust, no cracks, 1/16 - 1/8"

ii) Traffic Erosion (Spray)

a) Dilute at 1:3 with water

Apply at 2 gsy = 12¢/yd^2 (0.55 gsy attained = 4.8¢/yd^2)

iii) Traffic Erosion (Mixing)

a) Dilute at 1:3 with water

Apply at optimum (2.2 gsy) = 18.7¢/yd^2

No. 26

Name: Paracol 1461

Manufacturer: Hercules Inc.
One Maritime Plaza
San Francisco, California 94111

Chemical Constituents: Dispersion of a wax-thermoplastic resin blend

Properties: Color: Creamy tan

Smell: No odor

Wt/gal: 8.46 lbs/gallon

Sp. Gravity: 1.01

pH: 7 @ 25^{o} C.

Cost: $0.39/gallon F.O.B. Portland, Oregon

Recommended Use (Screening)

i) Wind Erosion

a) Dilute at 1:3 with water
Apply at 1 gsy = 9.8¢/yd^2

Reduced Rate:
Dilute at 1:9 with water
Apply at 1 gsy = 3.9¢/yd^2

Comments: Brown color, nominal crust, no cracks, 1-inch (but not hard) penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:1 with water
Apply at 1 gsy = 19.5¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:1 with water
Apply at 1 gsy = 19.5¢/yd^2

No. 27

Name: Terra-Krete #2

Manufacturer: Terra-Krete
3835 Bledsoe Ave.
Los Angeles, California 90066

Chemical Constituents: Vinyl acetate-acrylic copolymer

Properties: Color: Light green

Smell: No odor

Wt/gal: 8.58 lbs/gallon

Sp. Gravity: 1.03

pH: 2.3 @ 26^o C.

Cost: $1.85/gallon F.O.B. Torrence, California

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 6% solution in water
Apply at 1 gsy = 11.1¢/yd^2

Reduced Rate:

Dilute at 6% solution in water
Apply at 1/2 gsy = 5.6¢/yd^2

Comments: Natural color, hard crust, no cracks, 1/2-1 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 6% solution in water
Apply at 2 gsy = 22.2¢/yd^2 (1.6 gsy attained = 17.8¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 6% solution in water
Apply at optimum (2.2 gsy) = 24.4¢/yd^2

No. 28

Name: Terra-Krete #1

Manufacturer: Terra-Krete
3835 Bledsoe Ave.
Los Angeles, California 90066

Chemical Constituents: Fermented wort derived from substrates, aluminum sulfate, magnesium sulphate, citric acid, vanilla extracts, ferrous sulfate

Properties: Color: Tan
Smell: Strong odor
Wt/gal: 9.03 lbs/gallon
Sp. Gravity: 1.06
pH: 2.7 @ 26° C.

Cost: $5.00/gallon F.O.B. Torrence, California

Recommended Use: (Screening)

i) Wind Erosion
   a) Dilute at 0.6% solution with water
      Apply at 1 gsy = 3¢/yd^2

ii) Traffic Erosion (Spray)
   a) Dilute at 0.6% solution with water
      Apply at 2 gsy = 6¢/yd^2 (1.8 gsy attained = 5.3¢/yd^2)

iii) Traffic Erosion (Mixing)
   a) Dilute at 0.6% solution with water
      Apply at optimum (2.2 gsy) = 6.6¢/yd^2

Comments: When sprayed for wind erosion, natural color, nominal crust, no cracks, 1/4 - 3/8 inch penetration
Chemical biodegradable
Never add water to Terrakrete #1, always add Terrakrete #1 to water.

No. 29

Name: Ecology Control M-Binder

Manufacturer: Sta-Soil Corporation
5275 Craner Ave.
North Hollywood, California 91601

Chemical Constituents: Is derived from Plantago seed husk

Properties: Color: Brown

Smell: Seed-like

Wt/gal: granular

Sp. Gravity: -

pH: -

Cost: \$1.50/lb F.O.B. Phoenix, Arizona

Recommended Use: (Screening)

i) Wind Erosion

a) Make a solution of ratio 28 gms of chem + 1 gallon of water, spray at a rate of 1 gal of mix/yd^2 = 9.3¢/yd^2

b) Spray surface of sand with water at 0.5 gal/yd^2, sprinkle dry powder of chem. using a salt shaker on the surface at the rate of 28 gms/yd^2, spray water on the surface again with 0.5 gal/yd^2 = 9.3¢/yd^2.

ii) Traffic Erosion (Spray)

a) Spray the soil surface with water at 0.5 gal/yd^2, sprinkle dry powder chem. with a salt shaker at a rate of 56 gms/yd^2, spray surface again with 0.5 gal/yd^2 of water = 18.6¢/yd^2

iii) Traffic Erosion (Mixing)

a) Mix with soil enough chem. at rate of 56 gms/yd^2, add water to reach optimum = 18.6¢/yd^2

b) Mix with soil enough chem at rate of 84 gms/yd^2, add water to reach optimum = 28¢/yd^2

Comments: When sprayed for wind erosion, brown-hard crust, no cracks, it shrinks with time, leaving edges unprotected
Biodegradable
Not completely water soluble

No. 30

Name: Triton X-114 SB

Manufacturer: Rohm Haas and Company
Independence Mall West
Philadelphia, Pennsylvania 19105

Chemical Constituents: Alkyl Aryl Polyoxyethylene glycol

Properties: Color: Clear

Smell: Mild odor

Wt/gal: 8.2 lbs/gallon

Sp. Gravity: .987 @ 25^{o} C.

pH: 9.6 @ 26^{o} C.

Cost: $1.23/gallon F.O.B. Philadelphia, Pennsylvania

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:20 with water
Apply at 1 gsy = 5.9¢/yd^2

ii) Traffic Erosion (Spray)

a) Dilute at 1:20 with water
Apply at 2 gsy = 11.8¢/yd^2 (1.6 gsy attained = 9.4¢/yd^2)

iii) Traffic Erosion (Mixing)

a) Dilute at 1:20 with water
Apply at optimum (2.2 gsy) = 12.9¢/yd^2

Comments: When sprayed for wind erosion, natural color, nominal crust, no cracks, 1/16 - 1/4 inch penetration
Chemical is biodegradable

No. 31

Name: Corexit 7740

Manufacturer: Exxon Chemical Co.
8230 Stedman St.
Houston, Texas 77029

Chemical Constituents: A partially neutralized polyamide

Properties: Color: Dark brown

Smell: Slight odor

Wt/gal: 8.07 lbs/gallon

Sp. Gravity: .969

pH: 8.7 @ 26^{o} C.

Cost: $1.86/gallon F.O.B. Houston, Texas

Recommended Use: (Screening)

i) Wind Erosion

a) Make a 500 ppm solution in water
Apply at 1 gsy = 0.1¢/yd^2

Comment: Natural color, soft crust, no cracks

ii) Traffic Erosion (Spray)

a) Make a 500 ppm solution in water
Apply at 2 gsy = 0.2¢/yd^2

iii) Traffic Erosion (Mixing)

a) Make a 500 ppm solution with water
Apply at optimum (2.2 gsy) = 0.2¢/yd^2

No. 32

Name: Super-Crete-100

Manufacturer: Super-Crete, Inc.
2249 S. McQueen
Mesa, Arizona 85202

Chemical Constituents: Not given

Properties: Color: Clear

Smell: No odor

Wt/gal: 10 lbs/gallon

Sp. Gravity: 1.99

pH: 10.26

Cost: \$0.80/gallon F.O.B. Mesa, Arizona

Recommended Use: (Screening)

i) Wind Erosion

a) Use as is - no dilution
Apply at 1/10 gsy = 8¢/yd^2

Comments: Natural color, hard thick crust, no cracks, 1/8 inch penetration

ii) Traffic Erosion (Spray)

a) Use as is - no dilution
Apply at 1/10 gsy = 8¢/yd^2

iii) Traffic Erosion (Mixing)

a) Use as is - no dilution
Apply at 1/10 gsy = 8¢/yd^2

No. 33

Name: Aliquat H226

Manufacturer: General Mills Chemicals, Inc.
1712 W. Grant Road
Tucson, Arizona

Chemical Constituents: Dihydrogenated tallow dimethyl ammonium chloride

Properties: Color: White

Smell: No odor

Wt/gal: 7.1 lbs/gallon

Sp. Gravity: 0.85

pH: 9.0

Cost: $0.30/lb F.O.B. Kankakee, Illinois

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 6.5% solution with water
Apply at 1/2 gsy = 11¢/yd^2

Comments: White color, soft surface crust, no or some cracks, 1/32 inch thick layer

ii) Traffic Erosion (Spray)

a) Dilute at 6.5% solution with water
Apply at 1/2 gsy = 11¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 6.5% solution with water
Apply at 1 gsy = 22¢/yd^2

No. 34

Name: Petroset-RB

Manufacturer; Phillips Petroleum Co.
Bartlesville, Oklahoma 74003

Chemical Constituents: An oil-elastomer and water emulsion

Properties: Color: Cream

Smell:

Wt/gal; 8.4 lbs/gallon

Sp. Gravity: 1.05

pH: 6

Cost: $2.00/gallon F.O.B. Borger, Texas

Recommended Use: (Screening)

iii) Traffic Erosion (Mixing)

a) Apply at 3/16 gsy = 37¢/yd^2

Comments: Chemical separated and solidified; testing was not completed

No. 35

Name: Biobinder

Manufacturer: Pecoff Brothers Nursery and Seed, Inc.
Rt. 5, Box 215R
Escondido, California 92025

Chemical Constituents: "Organic soil stabilant" A liquid, water based product of hydrophobic and hydrophilic components

Properties: Color: Dark brown (tan)

Smell: Strong odor

Wt/gal: 8.5 lbs/gallon

Sp. Gravity: 1.02

pH: 8.7 @ 25^{o} C.

Cost: $2.57/gallon F.O.B. Escondido, California

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:14 with water

Apply at 0.7 gsy = 12¢/yd^2

Reduced Rate:

Dilute at 1:30 with water

Apply at 0.7 gsy = 5.8¢/yd^2

Comments: Medium brown color, hard crust, no cracks, 1/2 - 1 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:14 with water

Apply at 1 gsy = 17¢/yd^2 (3/4 gsy attained = 12.7¢/yd^2)

iii) Traffic Erosion (Mixing)

a) Dilute at 1:14 with water

Apply at 1 gsy = 17¢/yd^2

b) Apply same solution at 2 gsy = 34¢/yd^2

No. 36

Name: Surfax 5107

Manufacturer: E. F. Houghton and Co.
54 Tanforan Ave.
So. San Francisco, Ca. 94080

Chemical Constituents: Anionic wetting agent

Properties: Color: Clear, light colored

Smell: Strong odor

Wt/gal: 8.5 lbs/gallon

Sp. Gravity: 1.02

pH: 7.7 @ 26^{o} C.

Cost: $2.26/gallon F.O.B. So. San Francisco, Calif.

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:1000 with water
Apply at 2 gsy = 0.45¢/yd^2

ii) Traffic Erosion (Spray)

a) Dilute at 1:1000 with water
Apply at 2 gsy = 0.45¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:1000 with water
Apply at optimum (2.2 gsy) = 0.5¢/yd^2

Comments: When sprayed for wind erosion, natural color, soft, nominal crust, no cracks, wet entire sample
Chemical is biodegradable

No. 37

Name: Dust Control Oil

Manufacturer: Standard Oil Company of California
3443 N. Central Ave.
Phoenix, Arizona 85012

Chemical Constituents: A mixture of petroleum resin and a light hydrocarbon solvent.

Properties: Color: Dark brown

Smell: Slight odor

Wt/gal: 8.3 lbs/gallon

Sp. Gravity: 1.0

pH: 6 @ 26^{o} C.

Cost: $0.15/gallon F.O.B. Richmond, California

Recommended Use: (Screening)

i) Wind Erosion

a) Apply as is at 1/2 gsy = 7.5¢/yd^2

b) Apply as is at 1/4 gsy = 3.8¢/yd^2

Comments: Black color, soft, some cracks, 1/4 - 3/16 inch penetration

ii) Traffic Erosion (Spray)

a) Apply as is at 1 gsy = 15¢/yd^2 (0.6 gsy attained = 9¢/yd^2

iii) Traffic Erosion (Mixing)

a) Apply as is at 1 gsy = 15¢/yd^2

b) Apply as is at 1/2 gsy = 7.5¢/yd^2

No. 38

Name: Dust Stop

Manufacturer: Standard Brands Chemical Industries, Inc.
P.O. Box Drawer K
Dover, Delaware 19901

Chemical Constituents: An acrylonitrile butadiene styrene copolymer

Properties: Color: White

Smell: No odor

Wt/gal: 8.46 lbs/gallon

Sp. Gravity: 1.01

pH: 8.4 @ 25^{o} C.

Cost: \$1.10/gallon F.O.B. Dover, Delaware

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:20 with water
Apply at 1.5 gsy = 7.9¢/yd^2

Reduced Rate:
Dilute at 1:20 with water
Apply at 1/2 gsy = 2.6¢/yd^2

Comments: Natural color, hard crust, no cracks, 1/2 - 3/4 inch penetration

ii) Traffic Erosion (Spray)

a) Dilute at 1:20 with water
Apply at 2 gsy = 10.5¢/yd^2 (1.3 gsy attained = 6.8¢/yd^2

b) Dilute at 1: 10 with water
Apply at 2 gsy = 20¢/yd^2 (1.3 gsy attained = 13¢/yd^2)

iii) Traffic Erosion (Mixing)

a) Dilute at 1:20 with water
Apply at 2 gsy = 10.5¢/yd^2

b) Dilute at 1:10 with water
Apply at 2 gsy = 20¢/yd^2

No. 39

Name: Aquatain (liquid)

Manufacturer: Stabilization Chemicals
1440 S. Allec St.
Anaheim, California

Chemical Constituents: Adhesive mulch with a gum base

Properties: Color: Clear-gold

Smell: No odor

Wt/gal: 8.3 lbs/gallon

Sp. Gravity: 1.0

pH: 9.5 @ 26^{o} C.

Cost: \$2.30/gallon F.O.B. Anaheim, California

Recommended Use (Screening)

i) Wind Erosion

a) Dilute at 1: 5.5 with water
Apply at 1/4 gsy = 8.8¢/yd^2

Comments: When sprayed for wind erosion, natural color, soft, nominal crust, 3/16 inch penetration

Chemical is biodegradable

ii) Traffic Erosion (Spray)

a) Dilute at 1:5.5 with water
Apply at 1 gsy = 35¢/yd^2

iii) Traffic Erosion (Mixing)

a) Dilute at 1:5.5 with water
Apply at 1 gsy = 35¢/yd^2

No. 40

Name: Aquatain (c) Powder

Manufacturer: Stabilization Chemicals
1440 S. Allec St.
Anaheim, California 92805

Chemical Constituents: Gum of vegetable origin

Properties: Color: White to light green
Smell: No odor
Wt/gal: Powder
Sp. Gravity: -
pH: -

Cost: $5.00/pound F.O.B. Anaheim, California

Recommended Use: (Screening)

i) Wind Erosion
   a) Use a mix of 1.0 lb (powder) to 50 gallons of water
      Apply at 1/2 gsy = 5.2¢/yd^2

ii) Traffic Erosion (Spray)
   a) Use a mix of 1.0 lb (powder) to 50 gallons of water
      Apply at 2 gsy = 21¢/yd^2 (0.6 gsy attained 6.3¢/yd^2)

iii) Traffic Erosion (Mixing)
   a) Use a mix of 1.0 lb (powder) to 50 gallons of water
      Apply at 2 gsy = 21¢/yd^2

Comments: When sprayed for wind erosion, natural color, nominal crust, no cracks, 1/2 inch penetration
Chemical is biodegradable
Use high agitation to mix with water
Use fresh batch everytime.

No. 41

Name: Foramine Solution 99-194

Manufacturer: Reichhold Chemicals, Inc.
P.O. Box 1482
Tacoma, Washington 98401

Chemical Constituents: Urea-formaldehyde resin in water solution

Properties: Color: White-cream

Smell: Strong odor

Wt/gal: 10.7 lbs/gallon

Sp. Gravity: 1.28

pH: 7.7

Cost: $0.86/gallon F.O.B. Tacoma, Washington

Recommended Use: (Screening)

i) Wind Erosion

a) Make a solution of 0.18 lbs of water to each 1.0 lbs of chemical

Apply at 2 lbs/yd^2 = 13.6¢/yd^2

Reduced Rate:

Use same solution

Apply at 1 lb/yd^2 = 6.8¢/yd^2

ii) Traffic Erosion (Spray)

a) Apply same solution at 5 lbs/yd^2 = 34¢/yd^2

b) Apply same solution at 10 lbs/yd^2 = 68¢/yd^2

iii) Traffic Erosion (Mixing)

a) Apply same solution at 5 lbs/yd^2 = 34¢/yd^2

Comments: When sprayed for wind erosion light brown color, soft, some cracks, 3/16 inch penetration

Additional water had to be used to dilute the chemical (beyond 0.18 lb per 1 lb of chemical)

Chemical had to be kept at low temperature, otherwise it would harden and gel.

No. 42

Name: Plyamul 40-153 (emulsion)

Manufacturer: Reichhold Chemicals, Inc.
P.O. Box 1482
Tacoma, Washington 98401

Chemical Constituents: Vinyl acetate and dibutyl pthalate, water emulsion

Properties: Color: White

Smell: Strong odor

Wt/gal: 9.2 lbs/gallon

Sp. Gravity: 1.10

pH: 4.5 @ 27^{o} C.

Cost: $1.52/gallon F.O.B. Tacoma, Washington

Recommended Use: (Screening)

i) Wind Erosion

a) Use as is at 3/4 lb/yd^2 = 12.4¢/yd^2

Reduced Rate:

Use as is at 1/3 lb/yd^2 = 5.5¢/yd^2

ii) Traffic Erosion (Spray)

a) Use as is at 2 lb/yd^2 = 33¢/yd^2

iii) Traffic Erosion (Mixing)

a) Use as is at 2 lb/yd^2 = 33¢/yd^2

Comments: When sprayed for wind erosion, brown color, hard crust, no cracks, 7/16 inch penetration

Had to dilute with water to be able to spray and work with

No. 43

Name: Ashland Soil Stabilizer

Manufacturer: Ashland Oil, Inc.
P.O. Box 391
Ashland, Kentucky 41101

Chemical Constituents: Bituminous composition

Properties: Color: Black

Smell: Bituminous

Wt/gal: 8.4 lbs/gallon

Sp. Gravity: 1.0

pH: -

Cost: $0.50/gallon F.O.B. Ashland, Kentucky

Recommended Use: (Screening)

i) Wind Erosion

a) Use as is at 0.3 gsy = 15¢/yd^2

Comments: Black color, soft crust, 1/4 inch penetration, fragile, crust gel destroyed at 90 mph

ii) Traffic Erosion (Spray)

a) Use as is at 1 gsy = 50¢/yd^2

iii) Traffic Erosion (Mixing)

a) Use as is at 3/4 gsy = 37¢/yd^2

No. 44

Name: Compound SP-400

Manufacturer: The Johnson-March Corp.
3018 Market St.
Philadelphia, Pennsylvania 19104

Chemical Constituents: It is a blend of synthetic, organic long chain polymers in a water base

Properties: Color: Slightly white

Smell: Strong odor

Wt/gal: 9.4 lbs/gallon

Sp. Gravity: 1.13

pH: 10.4 @ 26^{o} C.

Cost: $2.45/gallon F.O.B. Philadelphia, Pennsylvania

Recommended Use: (Screening)

i) Wind Erosion

a) Dilute at 1:1 with water
Apply at 1 gal/ft^2 = 11¢/yd^2

Reduced Rate:
Dilute at 1:1 with water
Apply at 1/2 gal/ft^2 = 5.5¢/yd^2

Comments: Suggested for wind erosion only.

No. 45

Name: Foramine Dispersion 99-434-2

Manufacturer: Reichhold Chemicals Inc.
P.O. Box 1482
Tacoma, Washington

Chemical Constituents: Urea, Formaldehyde, water dispersion

Properties: Color: White-cream

Smell: Strong odor

Wt/gal: 10.2 lbs/gallon

Sp. Gravity: 1.26

pH: 7.10

Cost: \$0.82/gallon F.O.B. Tacoma, Washington

Recommended Use: (Screening)

i) Wind Erosion

a) Use solution of 0.15 lb of water to each 1 lb of chemical

Apply at 2 lbs/yd^2 = 14¢/yd^2

Reduced Rate:

Use same solution at 1 lb/yd^2 = 7.0¢/yd^2

ii) Traffic Erosion (Spray)

a) Use same solution at 5 lbs/yd^2 = 35¢/yd^2

iii) Traffic Erosion (Mixing)

a) Use same solution at 5 lbs/yd^2 = 35¢/yd^2

Comments: When sprayed for wind erosion, light brown color, soft, some cracks, 3/16 inch penetration

Additional water had to be used to dilute the chemical (beyond 0.18 lb per 1.0 lb of chemical)

No. 46

Name: Norlig-41 and F 125

Manufacturer: See No. 17 and No. 14 respectively

Chemical Constituents: No. 17 and No. 14

Recommended Use (Screening):

- i) Wind Erosion
  - a) Use a mix of (1:4) solution of Norlig 41 and (1:40) solution of F 125 at the ratio of 4:1
    Apply at 1 gsy = 9.1¢/yd^2

  Same as reduced rate
- ii) Traffic Erosion (Spray)
  - a) Use a mix of Norlig 41 concentrate and (1:40) solution of F 125 at the ratio of 1:1
    Apply at 1 gsy = 25.7¢/yd^2
- iii) Traffic Erosion (Mixing)
  - a) Same mix and rate as spray

Comments: When sprayed for wind erosion, brown color, hard crust, no cracks, 1/2 - 3/4 inch penetration

Chemical mixtures used to reduce water solubility of Norlig using F 125

Cost refers to prices F.O.B. Tucson, Arizona

APPENDIX C

ROTATING DISK RAINFALL SIMULATOR

Rotating Disk Rainfall Simulator

The original rotating disk rainfall simulator was designed by J. Morin during 1968 - 1970 at the Water Resources Research Center of the University of Arizona. For more detailed information on the rainfall simulator, it is suggested that the reader refer to papers by Morin, Goldberg, and Seginer (1967) and Morin, Cluff, and Powers (1970).

Morin et.al. (1970) stated that the major problem in rainfall simulation is achieving the combination of relatively low intensity with realistic drop sizes and high drop velocity. They proposed the use of a pressure controlled high capacity nozzle and slotted rotating disks for regulating the impact velocity and intensity would solve the problem. They found that nozzle 1-1/2 H30 produces rainfall characteristics more similar to natural rainfall than any other simulator used in the past. Figure 9 (in the text) illustrates the Rotadisk Rainulator which was built at the Civil Engineering Department based upon the original design by Morin et. al. (1970) as modified by Sultan (1971).

The rainfall simulator is equipped with the Spraying Systems Company Fulljet 1-1/2 H30 which utilizes a fully-cone-spray type nozzle. A slotted metal disk rotates on a vertical axis beneath the nozzle at a speed of 200 rpm. Drops from the nozzle reach the experimental area only when the aperture is under the nozzle. In any other position, the water strikes the circumference of the revolving disk and is drained away through a collector pan. The excess water is returned from the pan through a storage tank to the supply pump for repeated use. The high rate of application of the pressurized nozzle is thus reduced and regulated.

Mounted below the disk is a square collector pan with a convex bottom and an opening under the nozzle to pass the spray. The lower outer portion of the pan is used for excess water, which is returned to a storage tank through a pipe. A canvas sheet attached to the underside of the pan serves as a tent sheltering the sloping plot from stray water drops.

Connected to the storage tank is a water hose which supplies pressurized water to the nozzle by a 78 gpm (approximately) centrifugal pump driven by a one-horsepower electric motor.

Because the nozzle rotates at a 10° angle from the vertical and at a speed of 4 rpm, there is more accurate uniformity of rain over a larger area than achieved by other machines. An electric gear motor drives both the rotating disk and the nozzle.

In the rotating disk rainulator, the revolution of the disks with different size openings permits the production of intensities from close to zero to full nozzle capacity (60 inches per hour with a pressure of 0.6 atmosphere). The disks are made of 0.042 inch thick brass sheets shaped into hollow cones, with a 5° side slope and a 15.75-inch diameter.

The supporting frame is constructed from 1-1/4 inch aluminum pipe. The center of the slope position is fixed relative to the rainulator and is approximately 80 inches below the nozzle.

The specimen supporting frame can be adjusted at various slopes. The slopes that have been generally used in erosion studies at the soil stabilization laboratory are 4.5°, 14°, and 26.1° from the horizontal. Three different aperture angles in the rotating disks have also been used in previous studies, these are 5°, 15° and 20°. The combination of these slopes and aperture angles along with the pump pressure result in different rain intensities and distribution. A detailed calibration study for the rainulator was done by Sultan, Liu, and El-Rousstom (1971) and is also reported by El-Rousstom (1973). Another calibration was done and reported by Qaqish (1973).

The test set up in this project utilized a pressure of 12 psi (on the nozzle), a slope of 14° with the horizontal and an aperture opening of 15°. This combination results in an average rainfall intensity of 2.38 inches per hour, as given by Qaqish (1973).