Chemical Stabilization for Control of Dust and Traffic Erosion

Hassan A. Sultan, University of Arizona, Tucson

Forty-six commercially available chemicals were tested. Specimens of a dune sand sprayed with chemicals were subjected to simulated wind velocities up to 145 km/h (90 mph). Specimens of compacted granitic soil treated with chemicals by either spraying or mixing were subjected to simulated traffic abrasion forces under simulated tire pressures up to 414 kPa (60 psi). Selected chemical treatments were subjected to various environmental-durability conditions including freeze-thaw cycles, wet-dry cycles, rain-dry cycles, and various curing temperatures. Based on the results of this laboratory testing, several chemical stabilizers were selected for use in a large-scale field application. Eleven chemicals were sprayed on untraffickable areas to control dust and wind erosion. Five chemicals were sprayed on an unpaved road to control erosion and dust behind traffic. Three chemicals were also mixed with the surface of an unpaved road. Methods of field application and monitoring techniques including dust collection by a high-volume air sampler, dust fall collection in cups, and extraction tests are discussed. Preliminary comparisons of the chemical applications with themselves and with control sections, where water was used, are given. Evaluation will continue for approximately 12 months.

In arid and semiarid climates, soil erosion due to wind causes movement of cohesionless sandy soils and development of sand storms and high levels of dust particulates. In addition, unpaved gravel secondary roads require periodic grading and replacement of material lost through erosion due to traffic. Soil erosion due to both wind and traffic causes a significant increase in dust particulates in the atmosphere. The problem has already posed severe safety, health, and public relations problems and will continue unless positive measures for erosion control are developed and implemented.

EXPERIMENTAL PROGRAM

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

1. Screen the commercial market for chemical stabilizers that are potentially suitable for soil erosion control;
2. Select two soils, a wind-blown sand for studies of erosion due to wind and a common subgrade soil for studies of erosion due to traffic;
3. Determine the ability to reduce erosion due to wind of various chemicals sprayed on dune sand;
4. Determine the ability to reduce erosion due to traffic of various chemicals sprayed on or mixed with compacted subgrade soil;
5. Determine the durability of the stabilized soils under adverse environmental conditions (these tests were limited to those chemicals that performed best in the preliminary tests); and
6. Select several chemicals, based on the laboratory testing program, for use in field tests.

The durability tests include tests of erosion due to wind and traffic under freeze-thaw, wet-dry, and rain-dry cycles and various curing temperatures.

Chemical stabilizers were solicited from major manufacturers, suppliers, and formulaters. The letter of solicitation specified that the products should be nontoxic, nonflammable, noncorrosive, easy to handle and apply, and safe for plant or animal life should they leach out of the treated soil.

Cost of application was limited to 18 cents/m^2 (15 cents/yd^2) for nontraffickable areas (this was later reduced) and 90 cents/m^2 (75 cents/yd^2) for stabilization of traffickable unpaved roads.

Of approximately 170 manufacturers and suppliers contacted, 36 indicated willingness to participate in the project and forwarded 45 chemicals, which were used in this study (Table 1). Detailed information regarding these chemicals is given elsewhere (1).

TESTS OF EROSION DUE TO WIND

Initial Testing

Loose dry sand was placed in 15-cm-diameter by 5-cm-high (6 by 2-in) polyvinyl chloride (PVC) molds, at a nominal density of 1.55 g/cm^3 (97 lb/ft^3). Specimens were sprayed evenly with the recommended rate of chemical mixture by using a spray gun. Specimens were cured in an environmental room at 21°C (70°F) and 50 percent

Notice: The Transportation Research Board does not endorse products or manufacturers. Trade names appear in this report solely because they are considered essential to its object.

Publication of this paper sponsored by Committee on Chemical Stabilization of Soil and Rock.

relative humidity for 1, 3, and 7 days. After curing, separate specimens were tested for 3 min at 72.4 and 145-km/h (45 and 90-mph) simulated wind from wind blowers. The weight of material loss was corrected to dry basis and calculated as a percentage of the original weight of dry sand in the mold. Details of the testing procedures are given elsewhere (1).

Based on their performance in the initial test (resulting in less than 5 percent erosion), 27 chemicals were selected to undergo further testing to evaluate the durability of their stabilization potential after being subjected to adverse environmental conditions.

Freeze-Thaw Cycles

After being sprayed, the sand specimens were cured for 3 days in the environmental room. Specimens were then placed for 6 hours in a humid room [21°C (70°F)] where access to moisture was made available through continuous moisture spray and vapor. Specimens were then subjected to three freeze-thaw cycles. Each cycle consisted of 6 hours in a freezing room at -12.2°C (10°F) and 18 hours in a humid room at 21°C (70°F).

At the end of the third cycle, specimens were allowed to air dry to a constant weight in the environmental room. Duplicate specimens were then tested under 72.4 and 145-km/h (45 and 90-mph) wind velocity. The percentage of erosion was calculated as discussed above.

Wet-Dry Cycles

Similar specimens were subjected to three wet-dry cycles. Each cycle consisted of 6 hours in the humid room and 18 hours in the environmental room. The testing was the same as that for wind erosion.

Rain-Dry Cycles

Similar specimens were subjected to three rain-dry cycles. Each cycle consisted of 1 hour of rain at 6.04 cm/h (2.38 in/h) and 23 hours in the environmental room. Details of the Rotadisk Rainulator and procedures for testing are given elsewhere (1, 2, 3, 4). Specimens were tested for erosion due to wind, and the percentage of loss caused by erosion due to rain and wind was determined and reported separately.

Variable Curing Temperatures

Similar specimens were cured at 4.4 and 60°C (40 and 140°F) instead of 21°C (70°F) and then tested as were the specimens in the initial testing. This test was conducted to evaluate the influence of low and high temperatures on the stabilization effects of the chemicals.

Discussion of Test Results

The results of these environmental tests indicated that 20 chemicals (of 27 tested) successfully endured the conditions imposed. The rate of application of the chemical was reduced, and thus the cost of application was reduced to about 9.5 cents/m^2 (8 cents/yd^2).

The same tests were conducted on another set of treated specimens at the reduced rates, and the specimens were tested at a 145-km/h (90-mph) wind velocity. The results of the tests at the reduced rates were considered for further investigations.

Fourteen chemicals successfully endured the various environmental conditions to which they were subjected, and they provided a good measure of erosion control under a wind velocity of 145 km/h (90 mph). A selection criterion was arbitrarily set that eliminates any chemical treatment that resulted in a percentage of erosion due to wind equal to or greater than 5. The rain-dry cycles proved to be the most severe type of durability test condition in that it generally resulted in higher erosion than the other conditions.

The 14 chemicals that endured the tests were

1. Aerospray 70,
2. Petroset SB,
3. Dresinate DS-60W80F,
4. Terrakrete No. 2,
5. Aquatain (powder),
6. Plyamul 40-153,
7. Foramine 99-434-2,
8. Surfaseal,
9. Coherex,
10. Paracol 1461,
11. Dust Stop,
12. Foramine 99-194,
13. Polyco 2460, and
14. Norlig 41 + F125.

When we requested more Polyco 2460, Foramine 99-434-2, and Plyamul 40-153 for the field application, the suppliers reported that these chemicals had been discontinued mainly because their basic ingredients were unavailable during the energy shortage (January 1974). Aquatain (powder) was not considered for field testing because it is biodegradable and would lose effectiveness with time. Dust control oil was added to those chemicals used in the field application because of its superior field performance in another study completed at that time (5).

Most of the lignin-based products, e.g., Orzan GL-50, Norlig 41, and Soiltex, experienced their highest erosion after being subjected to the rain-dry cycles. This was expected because of 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 waterproofer (F125) that has sodium methyl siliconate as its major constituent. This mixture successfully reduced the solubility of the Norlig 41. This mixture was used throughout the study as chemical No. 46.

Chemicals Selected for Field Test of Erosion Due to Wind

Based on the test results, 11 chemicals were used in the field test phase of this project. The rates of application selected were the reduced rates. The chemicals used in the field application (water was used as the control section) were

1. Aerospray 70,
2. Petroset SB,
3. Terrakrete No. 2,
4. Foramine 99-194,
5. Dresinate DS-60W-80F,
6. Dust control oil,
7. Surfaseal,
8. Paracol 1461,
9. Dust Stop,
10. Coherex, and
11. Norlig 41 + F125.

TESTS OF EROSION DUE TO TRAFFIC

Spray Application

Tests were conducted to evaluate the degree of stabilization effected by spraying the chemicals on a compacted road surface subjected to the abrasive action of traffic.

The spray treatment simulates a postconstruction application for unpaved (dirt) roads on which it may not be feasible to mix the chemical with the subgrade before compaction. Granitic soil was used exclusively in tests of erosion due to traffic.

The apparatus used was a modification of a design reported by Gallaway and Jimenez (6). The apparatus consists of four rubber rollers mounted on a shaft that, in turn, is mounted on a small steel frame. Bolted to the top of the frame is an 11-cm-long (4.5-in) shaft. The top portion of the shaft was inserted in the rotating sleeve of a mechanical bituminous mixer that 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 the resulting imprint contact pressure between the rubber rollers and a flat soil surface can be varied at 27, 310, and 414 kPa (30, 45, and 60 psi). Granitic soil mixed at optimum moisture content was compacted in the PVC molds to a maximum dry density of 2.05 g/cm^3 (128 lb/ft^3) as determined by AASHTO T-180. The specimens were then placed in the environmental room for 7 days to reach constant weight. Specimens were then sprayed evenly at the recommended rate of chemical by using a spray gun. One set of specimens was then cured for 3 days and another for 7 days in the environmental room.

After curing, the specimen was weighed, placed under the abrasion apparatus at a contact pressure of 414 kPa (60 psi), and tested for 10 min. During the test, a small wind blower was directed at the top of the specimen to remove abraded particles. At the end of the abrasion test, the specimen's final weight was recorded. The ratio of the weight loss, corrected to dry weight, to the weight of dry soil in the compacted specimen was reported as the percentage of erosion. Chemical treatments resulting in an abrasion loss of less than ½ percent were considered worthy of further testing.

Nineteen chemicals (of 46) were selected to undergo further testing after being subjected to adverse environmental conditions.

Freeze-Thaw Cycles

Specimens were compacted, cured for 7 days in the environmental room, sprayed with chemicals, and then allowed to cure for 7 days in the environmental room, as described before. Specimens were placed for about 2 hours on moist pads where water was made accessible to the bottom of the specimens. Specimens were then subjected to three freeze-thaw cycles. Each cycle consisted of 6 hours in the freezing room and 18 hours in the environmental room. At the end of the third cycle, the weight of each specimen was recorded and then tested under a 414-kPa (60-psi) contact pressure for abrasion. At the end of the test, the ratio of the corrected weight loss to the weight of the dry soil in each compacted specimen was reported as the percentage of erosion.

Wet-Dry Cycles

Similar specimens were subjected to three wet-dry cycles consisting of 6 hours in the humid room and 18 hours in the environmental room. They were then tested for abrasion.

Rain-Dry Cycles

Similar specimens were subjected to three rain-dry cycles consisting of 1 hour of rain at 6.04 cm/h (2.38 in/h) and 23 hours in the environmental room and were then tested for abrasion.

Variable Curing Temperatures

After being sprayed, similar specimens were cured at 4.44 and 60°C (40 and 140°F) instead of 21°C (70°F) for 7 days and were then tested as were the specimens in the abrasion test.

Of the 19 chemicals tested, eight effectively endured the test conditions and resisted the simulated tire abrasion under 414 kPa (60 psi) of pressure with erosion losses of less than ½ percent. These chemicals were

1. Aerospray 70,
2. Polycol 2460,
3. Plyamul 40-153,
4. Foramine 99-434-2,
5. Curasole AE,
6. Foramine 99-194,
7. Ashland oil stabilizer, and
8. Norlig 41 + F125.

In addition, one chemical, Dust Bond 100, resulted in similar effective degrees of control, except at the curing temperature of 4.44°C (40°F).

Results

Both the 4.44°C (40°F) curing temperature and the rain-dry cycles proved to be the most severe types of durability test conditions inasmuch as they generally resulted in the highest erosion.

Again, several chemicals could not be delivered by manufacturers in sufficient quantities for the field application. These were Polyco 2460, Foramine 99-434-2, Plyamul 40-153, Ashland oil stabilizer, and Norlig 41. Therefore, only three of the eight chemicals that proved effective were available for field testing. Inasmuch as Dust Bond 100 (which is also a lignin sulfonate product) was available, it was used in place of Norlig 41 in the mixture with F125 as chemical No. 46. In addition, because of the successful experience in field application of dust control oil (5) and its reasonably good laboratory results, this chemical was included in the chemicals used in the field test. Accordingly, five chemicals were used in the field application, in addition to water (control section):

1. Aerospray 70,
2. Dust Bond 100 + F125,
3. Foramine 99-194,
4. Curasole AE, and
5. Dust control oil.

Mixing Application

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

In this case, the soil, water, and chemical solution were mixed together before compaction. After compaction, one set of specimens was cured for 3 days and another for 7 days in the environmental room. At the end of the curing period, the specimens were tested for abrasion at a simulated tire pressure of 414 kPa (60 psi), as discussed before. Chemical treatments resulting in abrasion loss of less than ½ percent were considered worthy of further testing.

Based on their performance in this test, only seven chemicals were selected to undergo further testing to evaluate their stabilization potential under adverse environmental conditions. These chemicals were

1. Redicote E-52,
2. Norlig 41,
3. Soiltex,
4. Norlig 41 + F125,
5. Orzan Gl-50,
6. Dust Bond 100, and
7. Ashland oil stabilizer.

It is interesting to note that five of these seven chemicals have lignin sulfonate as a base material.

The environmental-durability tests included freeze-thaw cycles, wet-dry cycles, rain-dry cycles, and various curing temperatures. Details of the durability tests are similar to those discussed previously.

Under 414 kPa (60 psi) of simulated tire pressure, only Norlig 41 + F125 was effective (with erosion loss of less than ½ percent) under all durability conditions. A similar degree of effectiveness was given by Redicote E-52, Norlig 41, Dust Bond 100, Soiltex, and Ashland oil stabilizer except under one or two of the durability conditions imposed.

Chemicals with a lignin sulfonate base provided the best performance in the traffic abrasion tests of the mixed specimens; we were also successful in waterproofing (reducing solubility) the Norlig 41 treatment by adding F125.

Because it was unrealistic and unnecessary to use three or four different lignin-based chemicals in the field application, Norlig 41 was chosen to represent this group of chemicals. However, because the manufacturer was unable to deliver large quantities at that time, Dust Bond 100 was used instead of Norlig 41 in composition of chemical No. 46. Accordingly, Redicote E-52 and a mixture of Dust Bond 100 plus F125 were recommended for field application. At this time the supplier of dust control oil indicated his willingness to donate the chemical for field application by spraying and mixing. Therefore, the field application included the Redicote E-52, Dust Bond 100 + F125, and dust control oil.

FIELD TESTING PROGRAM

Dust Control Test

Two sites were used to test the application of the chemical spray to control dust on untrafficable areas. Each site was cleared, leveled, and smoothed before spraying. Each chemical was allocated a designated area of 6 by 12 m (20 by 40 ft). Chemical solutions were prepared in and sprayed with a mobile sprayer having a 190-liter (50-gal) capacity. The rates of application were adjusted beforehand by calibrating the output of the sprayer.

Two months after the application of chemical on the first site (a former farm area), weeds started to grow profusely, aided by the heavy summer thunderstorms. In an actual field application this may not be considered a problem because weeds tend to provide an additional measure of dust control. However, on a test site, they did present a problem because they obscured the conditions of the sprayed surfaces. Therefore, another site was selected and sprayed with the chemicals to which Princep-80W, a weed control agent containing 80 percent Simazine as an active ingredient, was added. The recommended rate of application for Princep-80W was set at 11.2 kg/ha (10 lb/acre).

The techniques used for evaluating the performance of the chemical applications on the dust control sites (untrafficable) were developed by the writer (1, 5). These methods, briefly outlined below, were conducted on a biweekly basis.

Sampling of Windblown Dust

A small blower was used as a wind simulator to stir dust particles off the surface. The blower was placed on an inclined steel support such that the air flow would hit the ground surface at an angle of about 40 deg with the horizontal (1, 5). The wind velocity at the mouth of the blower was about 19 km/h (12 mph) and decreased to approximately 13 km/h (8 mph) at the point of impact on the ground. A high-volume air sampler (HiVol) (7) was placed 1.2 m (4 ft) away from the blower along the direction of wind flow. A glass-fiber filter paper 20 by 25.4 cm (8 by 10 in) in size was used to collect the dust particulates on it.

Sampling was conducted with the wind blower on, and the HiVol drawing air at 1.4 m^3/min (50 ft^3/min) over a 5-min period. The amount of dust collected was computed in micrograms per cubic meter. The development and modification of this test and the reasoning behind the chosen parameters are given elsewhere (1).

Sampling for Extraction Test

Soil samples from the surface of the treated zones were obtained and used in an extraction test to determine the amount of benzene or water-soluble organic matter or both present. Comparing the amounts extracted from samples at different periods after application gives a quantitative evaluation of the degree of leaching of the chemical. The weight of the extracted organics was measured to the nearest milligram and converted, according to the area of extraction sample, into grams per square meter. The extraction procedure is outlined elsewhere (1, 5) and is very similar to that outlined by the Public Health Service (8).

Visual Inspection and Evaluation

In addition to the quantitative evaluation techniques discussed above, a qualitative evaluation is being made periodically on the condition of each test plot. This evaluation includes condition of the surface, thickness and firmness of crust, color change, cracks, and vegetation growth. This inspection supplements the other tests and helps to spot erratic or unexpected results.

Road Test

Spraying Application

A road test site was selected on a dirt (gravel) road just south of I-10 east of Tucson. Ten sections 183 m long (600 ft) and 8.5 m wide (28 ft) were marked along the road. One section was used for each chemical treatment. For applications by spraying, the surface of the road was usually prepared by surface blading (no ripping), which left a nominally loosened surface layer. The chemical solution was prepared in a boot truck and sprayed on the surface through the spray bar. The boot truck was equipped with a circulating pump that continued to mix the chemicals during application. After it was sprayed, the surface was usually rolled with a rubber-tired roller.

Mixing Application

For the mixing application, the road surface was sprayed lightly with water, and then the surface was ripped up, by using a ripper attached to the grader, to a depth of about 7.6 cm (3 in). A mixed and compacted mat of this thickness was selected because a Seaman mixer was not available and based on field results reported by Hoover (9). Because Hoover (9) had difficulty in mixing and compacting a ripped 10-cm-thick (4-in) layer, he recommended future use of 7.6-cm (3-in) thickness. After the road surface was ripped up, additional water was sprayed to reduce surface tension effects, and then a portion of the required chemical application was sprayed on the surface. The loosened surface soil was then bladed to the sides of the roads to form two windrows. Each windrow was then spread back on the road surface, sprayed with more chemical and water if necessary, and then bladed to form a windrow in the middle of the road. When all the required chemical and enough water (to reach optimum moisture in the field) had been added, a continuous operation of surface mixing by the blade was done. After complete mixing, two side windrows were formed. The mixed soil was then spread on the surface and compacted in two lifts, forming a slight crown near the center. The field techniques used for evaluating the performance of the chemical applications were developed and discussed elsewhere (1). The methods are briefly outlined below.

Table 1. Chemicals used in laboratory and field test.

No.	Chemical	No.	Chemical
0	Water (control)	24	Enzymatic SS-2
1	Soil stabilizer 801	25	Dresinate DS-60W-80F
2	Compound SP-301	26	Paracol 1461
3	White soil stabilizer	27	Terra-Krete No. 2
4	Stikvel P 65	28	Terra-Krete No. 1
5	Velsicol W-617	29	Ecology control M-binder
6	Redicote E-52	30	Triton X-114 SB
7	Aerospray 70	31	Corexit 7740
8	Aerospray 52	32	Super Crete 100
9	Curasol AE	33	Aliquat H226
10	Polyco 2190	34	Petroset-RB
11	Polyco 2460	35	Biobinder
12	Orzan GL-50	36	Surfax 5107
13	Surfaseal	37	Dust control oil
14	Formula 125	38	Dust stop
15	Enzymatic SS-1	39	Aquatain (liquid)
16	RTD-SS-X	40	Aquatain C (powder)
17	Norlig 41	41	Foramine 99-194
18	Dust Bond 100	42	Plyamul 40-153
19	Sodium silicate grade No. 9	43	Ashland soil stabilizer
20	Petroset SB	44	Compound SP-400
21	Coherex	45	Foramine 99-434-2
22	Soiltex	46	Norlig 41 + F125
23	Thermoset 401		

Sampling of Windblown Dust

This test is the same as that discussed for the dust control sites and was conducted on each section of the road test.

Dust Collectors Across the Road

Dust collectors were installed across the road at the middle of each section. The dust collectors consisted of plastic cups that were taped to the top of 5-cm-wide (2-in) plywood sticks, with their top approximately 0.9 m (3 ft) above the ground. The containers were half-filled with distilled water and covered at the top with a wire screen with square openings 2 mm (0.78 in) in size. The screen was taped to the side of the cup to prevent insects from crawling into the cup, which occurred when only a rubber band was used.

The cups were placed at a spacing of 6.1 m (20 ft) for a distance of 43 m (140 ft) and at 15.2-m (50-ft) spacing

Table 2. Preliminary observations of dust control and road tests.

Item	Chemical No.	Highest HiVol Collection ($\mu g/m^3$)	Description[a]
Dust control test	0	64 301	Natural color, thin soft crust, some cracks
	7	8 751	Light brown, hard crust 4.8 mm thick, some cracks
	13	2 972	Brown, very hard crust 6.4 mm thick, some cracks
	13	6 397	Light brown, hard crust 4.8 mm thick, some cracks
	20	8 312	Natural, hard crust 4.8 mm thick, some cracks
	21	4 857	Natural, medium crust 4.8 mm thick, some cracks
	25	7 122	Natural, hard crust 4.8 mm thick, cracks
	26	8 949	Natural, hard crust 4.8 mm thick, cracks
	27	2 478	Natural, hard crust 6.4 mm thick, light cracks
	37[b]	3 441	Black, soft crust 7.9 mm thick, light cracks
	38	5 862	Natural, hard crust 4.8 mm thick, some cracks
	41	8 921	Natural, very weak crust 1.58 mm thick, many cracks
	46	4 490	Light brown, hard crust 4.8 mm thick, some cracks
Road test, spraying application	0	63 367	Natural color, soft when wet, worn, rutted, large amount of loose material, large cloud of dust behind traffic
	7	4 932	Brown color, medium hard surface, medium wear and few ruts, small amount of loose material, light dust behind traffic
	9	4 191	Dark brown, hard surface but worn, rutted with several potholes, substantial loose material on surface, moderate dust behind traffic
	18	5 286	Brown, hard surface, little wear, smooth surface with little loose material, very light dust behind traffic
	37	1 352	Black, very hard surface, some potholes near shoulders, minimal loose material, extremely light dust behind traffic
	41	16 918	Natural color, soft, worn and rutted surface, poor riding quality, large amount of loose material, almost as if untreated
Road test, mixing application	0	41 334	Natural color, soft when wet, worn, rutted, substantial amount of loose material, large dust cloud behind traffic
	6	1 246	Black, very hard, asphaltlike surface, little wear, fairly smooth, no loose material, no dust behind traffic
	18	1 897	Brown, hard surface, smooth, little wear, some loose material, very light dust behind traffic
	37[c]	3 618	Black, hard in spots, many potholes and ruts, large loose material on surface, moderate dust behind traffic
	37[d]	5 111	Black, hard in spots, very worn with ruts and potholes, substantial loose material, moderately heavy dust behind traffic

[a]Descriptions are of condition of plot for dust control test and condition of road for road test. [b]Application was 0.45 dm^3/m^2 (0.1 gal/yd^2). [c]Section 10a. [d]Section 10b.

for an additional 31 m (100 ft) at both sides of the road. The cups were left in place for 21 days and were periodically checked to ensure that there was sufficient water in them. This test was considered to be relatively simple yet conforms, as nearly as possible, to ASTM D 1739 for collecting and analyzing dust fall. The distance adopted for dust collection across the road, 73 m (240 ft) on both sides, was based on the results of similar testing reported by Hoover (10), where the dust collected showed a very rapid drop-off from the road shoulder out to 9 to 12 m (30 to 40 ft), followed by a more gradual drop to about 46 m (150 ft). Beyond 46 m (150 ft) a nearly constant low deposition rate was reported (10).

At the end of the collection period, the cups were sealed and taken to the laboratory. Details of the laboratory filtration and determination of nonvolatile solids (dust particles) are given by Sultan (1). This test will be conducted three or four times during the entire monitoring period of 15 months.

Visual Inspection and Evaluation

In addition to the quantitative evaluation techniques described above, a qualitative evaluation is made periodically of the condition of each test section. This evaluation includes condition of the road surface, degree of dust control during traffic, riding quality, ruts, potholes, and surface cracking.

PRELIMINARY FIELD RESULTS

The following field data, results, and observations are reported after only 3 months of field monitoring. Therefore, they should be viewed as preliminary.

Dust Control Test

Preliminary observations for the various treated plots are given in Table 2. The highest value was reported because the site has been abnormally wet during the observation period.

Based on the data given in Table 2 and general field conditions, the top five of the applied chemicals in terms of performance are as follows:

1. Terrakrete No. 2,
2. Surfaseal 1:10,
3. Dust control oil, 1.13 liter/m^2 ($^1/_4$ gal/yd^2),
4. Norlig 41 + F125, and
5. Coherex.

As stated previously, because of the short period of evaluation and the moist condition of the surface due to heavy rains, these data are preliminary.

Road Test

Spraying Application

Preliminary observations for the various sections of the road treated with chemicals applied by spraying are also given in Table 2. Based on the data given in Table 2 and the general road conditions, a preliminary performance rating of the chemicals is as follows:

1. Dust control oil,
2. Dust Bond 100 + F125,
3. Aerospray 70,
4. Curasol AE, and
5. Foramine 99-194.

Mixing Application

Preliminary observations for the various sections of the road treated with chemicals applied by mixing are given in Table 2. The observations include the road condition, color, riding quality, observed dust behind traffic, loose material on the surface, and highest recorded concentration based on Hi Vol readings.

Based on the data given in Table 2 and the general road conditions, a preliminary performance rating for the applied chemicals may be given as follows.

1. Redicote E-52,
2. Dust Bond 100 + F125, and
3. Dust control oil.

CONCLUSIONS

1. Based on laboratory test results, many commercially available chemical stabilizers proved their capability in significantly reducing erosion of dune sands under simulated wind velocities of up to 145 km/h (90 mph) after being subjected to adverse environmental conditions.
2. Laboratory studies indicate that several chemicals can be applied either by spraying or mixing and the stabilized surfaces can resist simulated traffic abrasion under a simulated contact pressure of 414 kPa (60 psi).
3. Preliminary field results indicate that the chemicals adequately control dust and resist erosion due to wind on untrafficable areas, at application costs of less than 10.8 cents/m^2 (9 cents/yd^2).
4. Preliminary field results for the road application are less encouraging than those for untrafficable areas. This indicates less direct correlation between laboratory results and field performance for treatments subjected to traffic effects. However, a few chemicals successfully reduced erosion under traffic on an unpaved road, at a treatment cost of less than 71.8 cents/m^2 (60 cents/yd^2) for a 7.6-cm (3-in) mat.

ACKNOWLEDGMENTS

This investigation was conducted at the Arizona Traffic and Transportation Institute, University of Arizona. The author wishes to thank the sponsors, the Arizona Department of Transportation and the Federal Highway Administration, U. S. Department of Transportation.

REFERENCES

1. H. A. Sultan. Soil Erosion and Dust Control on Arizona Highways—Part 2: Laboratory Testing Program. Arizona Department of Transportation and Federal Highway Administration, Rept. ADOT-RS-10-141-11, 1974.
2. J. Morin, C. B. Cluff, and W. R. Powers. Realistic Rainfall Simulation for Field Investigation. Paper presented at Fifty-first Annual Meeting of the American Geophysical Union, Washington, D.C., 1970.
3. H. A. Sultan. Rain Erosion Control Studies. Engineering Experimental Station Project EES 123/70, 1970.
4. A. K. El-Rousstom. Rain Erodibility of Compacted Soils. Univ. of Arizona, Tucson, PhD dissertation, 1973.
5. H. A. Sultan. Evaluation of Dust Control Oil and Coherex. Prepared for Right-of-Way Section, Arizona Highway Department, Rept. AHD-RD-234, 1974.
6. B. M. Gallaway and R. A. Jimenez. Interim Report

on a Study of Laboratory Method to Determine Susceptibility to Raveling of Bituminus Mixtures. National Bituminous Concrete Association, QIP65, 1963.
7. C. I. Harding and E. R. Hendrickson. Manual for Calibration and Use of High Volume Air Samplers in the Measurements of Suspended Particulate Matter. Engineering and Industrial Experiment Station, Univ. of Florida, Gainesville, Bulletin 117, Aug. 1964.
8. Air Pollution Measurements of the National Air Sampling Network Analysis of Suspended Particulates 1957-1961. Public Health Service, Publ. 978, 1962.
9. J. M. Hoover. Surface Improvement and Dust Palliation of Unpaved Secondary Roads and Streets. Engineering Research Institute, Iowa State Univ., Iowa Highway Research Board Project HR-151, Progress Rept., June 1971.
10. J. M. Hoover. Surface Improvement and Dust Palliation of Unpaved Secondary Roads and Streets. Engineering Research Institute, Iowa State Univ., Iowa Highway Research Board Project HR-151, Final Rept., July 1973.