Comprehensive Field Studies to Address Performance of Chemical Dust Palliatives

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Abstract

Chemical dust palliatives have been used for decades to reduce the harmful or impeding effects of airborne dust on vehicle maneuvers. Improvements in the efficiency of these products have derived from increasing market potential as environmental regulations have tightened for air quality compliance. The research described herein was dedicated to quantifying the performance of traditional, newly developed, and experimental chemical dust palliatives. Data were analyzed from four field test locations to determine the effectiveness and durability of these dust palliatives. Two field tests were conducted in Yuma, AZ to evaluate performance under rotary-wing aircraft landings in an arid environment. Additional testing in an arid environment was conducted in Douglas, AZ for mitigating dust on unpaved roads. A final test was conducted at Ft. Leonard Wood, MO to evaluate the effectiveness of chemical dust palliatives in a temperate climate. A particulate monitoring system was used to quantify the amount of dust generated from treated soil on test sections when controlled traffic was applied during each field test. Additional soil testing aided researchers in understanding the phenomenon of dust generation and the interaction of chemical dust palliative with the soil. Results from these tests were used to develop a decision-aid for selecting and applying products for dust mitigation.

Introduction

Dust generation in military operations can create major obstacles that impact mobility requirements and personnel. Brown out conditions during rotary wing aircraft landings and severe visibility loss along ground convoy routes were significant problems during Operations Enduring and Iraqi Freedom. Safety and health issues associated with these problems illuminate the need for methods to rapidly suppress dust. With numerous products available on the commercial market, controlled evaluations are needed to evaluate product effectiveness and to prescribe methods to effectively use products. The series of tests described in this paper were conducted in support of the Marine Corps Systems Command in an effort to develop dust mitigation systems for overseas operations.

Dust Palliatives

Polymer emulsions

[redacted], [redacted], [redacted], [redacted], [redacted], [redacted], and Soiltac® are classified as polymer emulsions. These products are generally vinyl acetate or acrylic-based copolymers suspended in an aqueous phase by surfactants. They typically consist of 40 to 50 percent solid particles by weight of emulsion. Once they are applied, the polymer particles begin to coalesce as the water evaporates from the system, leaving a soil-polymer matrix that prevents small dust particles from escaping the surface. The polymers used for dust control typically have excellent tensile and flexural strengths, adhesion to soil particles, and resistance to water.

Synthetic fluids

Durasoil® and [redacted] are synthetic organic fluids that are designed to be applied to a soil “as received.” These fluids are not miscible with water and therefore are unable to be diluted. They consist of isoalkanes that do not dry or cure with time. The reworkable binder is ready for immediate use upon application and maintains effectiveness over extended periods of time.

Chloride salt

[redacted] is a solution of calcium, magnesium, and sodium chlorides. The solution typically contains approximately 38 percent chloride salt by weight. The material obtained for this test contained 40 percent chloride salt to reduce shipping volumes. This deliquescent material has been used for many years as a low-cost solution for dust problems. It maintains effectiveness by absorbing moisture from the air and binding soil particles together. Long-term efficiency of chloride salts are sometimes limited because the material is water-soluble and will leach from the soil with prolonged exposure to rainfall. Chloride salts are also known to be a highly corrosive material and will increase maintenance requirements for equipment operating on areas on which they have been sprayed.

Polysaccharide

Surtac® is a polysaccharide-based system composed of sugar, starch, and surfactants suspended in an aqueous solution. It is shipped in a concentrated form that may be diluted depending upon its intended use. Surtac® provides dust abatement by encapsulating soil particles and creating a binding network throughout the treated area. The binder is water soluble and reworkable. However, it is also susceptible to leaching from the soil with heavy rainfall.

Powdered polymer

Powdered Soiltac® is a water-soluble powder that provides dust abatement by encapsulating soil particles and creating a binding network throughout the treated area. The binder is water-soluble initially, but upon curing forms a non-soluble film.

Emulsified rubber

[redacted] is an elastic, polymeric material suspended in water. It provides dust abatement through mechanisms similar to that of the polymer emulsions; however, the binder is much more flexible. The emulsion is approximately 50 percent solid material by weight. [redacted] is an experimental product developed for this test.

Lignosulfonates and Rosins

[redacted] and [redacted] are products that are derived from tree rosins or a byproduct of pulpwood processing. They provide dust control by physically binding soil particles. They are usually sold as an emulsion, but they can be purchased in powder form. They are characterized by a distinct odor and dark color. They are susceptible to leaching from the soil in areas of high moisture or precipitation. Products used in this study were delivered as emulsions.

Polyacrylamide

[redacted], [redacted] and [redacted] are polyacrylamides. Polyacrylamides are water-soluble polymers that provide dust control through moisture retention. These materials are used as super-absorbents in baby diapers, chemical spill containment, and other applications. They are generally applied in powder or granular form because polyacrylamides cause very large increases in viscosity when dissolved in water. Polyacrylamides swell when they come in contact with water and may cause volume changes in the soil. For this reason, they are not recommended for use on roads.

Evaluation Procedures

Several evaluation tools were used to determine the effectiveness of each dust abatement method on the constructed test sections. Soil classification and in situ property measurements were used to identify the mechanisms by which the dust palliatives performed. Dust collection systems were used to quantify the amount of material dislodged from the road surface during trafficking. The effectiveness of each product was evaluated based on test results and visual observations.

Stationary Dust Sampling

The stationary dust collection systems used in this evaluation consisted of two dust collectors manufactured by General Metal Works, Inc. Each collector consisted of a paper filter placed over a wire mesh screen through which a slight vacuum pressure was drawn using an electric vacuum pump. They were placed on the downwind sides of helipads or road test sections. Traffic was applied to the section to create dust. The filters were then removed and weighed to determine the amount of material collected.

Mobile Dust Sampling

Midwest Research Institute (MRI) was contracted by ERDC to perform dust collection during the Douglas test using a tow-behind evaluation system. The device uses a filter system mounted onto a 21-ft aluminum bar that was attached to the bed of a pickup. This type of system allows for continual measurement directly behind the vehicle. The number of passes made over the section was governed by the amount of dust emerging from behind the vehicle. The sections producing very little dust were trafficked more times than the others in order to get a significant amount of material on the filters. The data was then normalized to the amount collected per 1000 ft of testing.

A mobile dust sampler was fabricated by the ERDC for use during the Fort Leonard Wood dust tests. An aluminum shell with a 5.1 cm (2-in.) diameter intake nozzle was placed over the top of the filter. A slight vacuum, drawn through an electric vacuum pump, pulled dusty air from behind the vehicle and through the filter. The filter was then removed and weighed to determine the amount of material collected. The system was mounted on a bar attached to the receiver of the towing package on the test vehicle. The intake nozzle was located 2.4 m (8-ft) behind the vehicle and 0.9 m (3-ft) above the ground. Ten vehicle passes were applied to each test section at a speed of 48 km/hr (30 mph). A rheostat was installed between the generator and dust sampler to allow operation of the system from within the cab of the test vehicle. Testing was performed in the center 152 m (500-ft.) of the test sections to avoid interference from the untreated areas at their ends.

Visual Inspection Rating

During the dust collection process, each section was rated based upon the visually perceived effectiveness of the dust palliative. The rating ranged from one (blinding dust) to ten (no visible dust). The numerical ratings correlate to the clarity of the air. For example, if visibility is reduced to about 30 percent during vehicle movement, the section would receive a three for the visual rating. The initial values for each section, prior to treatment, were considered to be “one”. Immediately after treatment each section was given a rating of “ten”. This method was used to differentiate product effectiveness among the different test sections and to determine the validity of the results from the dust collection systems.

Helipad Dust Abatement

Field Trial 1

The first field evaluation of dust palliatives took place in January and February 2004 at the Marine Corps Air Station (MCAS) Yuma, AZ. The field evaluation was coordinated in conjunction with a “Desert Talon” exercise being conducted at MCAS Yuma. The field site consisted of open desert located immediately north of the Auxiliary II assault landing strip. The site was cleared of native vegetation prior to product application using a motor grader and bucket loader. The soil was classified as a poorly-graded sand with silt (SP-SM) according to the Unified Soil Classification System (USCS). Once the surface crust was disturbed, the graded sand was very loose to a depth of 10 to 12 inches. The remolded shear strength of the loose sand was measured using a Geonor vane shear device and averaged 22 kPa or 3.2 psi, which correlates to a 0.7 CBR or a cone index of 30. Eighteen 115-ft by 130-ft helipads were outlined with each helipad separated by a 75-ft by 130-ft graded sand untreated buffer zone. Table 1 provides a description of each helipad in terms of the product name, amount of product used, quantity of water used, total amount of diluted product used, and the initial number of CH-46 aircraft operations conducted on 21 January 2004 after three days of curing. As shown, only seven helipads were tested on 21 January 2004 to allow equivalent curing times on the remaining helipads prior to traffic. Additional traffic was scheduled for these and the remaining helipads for 22 through 24 January including more UH-1, AH-1, CH-46, and CH-53 aircraft. However, the additional traffic was postponed due to receiving up to 0.5 in. of rainfall on the evenings of 21 and 22 January 2004. Additional flight tests were conducted with CH-46 and CH-53 aircraft in February 2004.

CH-46 and CH-53 rotary-wing flight tests were resumed on 18 February 2004, approximately 30 days after initial product application. Each helipad was subjected to one “dustoff” and three landing sequences. The initial “dustoff” consisted of landing the aircraft on each helipad to blow off any loose debris that had accumulated during the test postponement or from adjacent aircraft operations. Each landing sequence consisted of a transition from forward flight to landing, a vertical climb, 50-ft hover, and departure. The landing sequence was modified from the initial flight test to reduce the time per cycle in order to complete the testing within the allotted flight window. Stationary dust collectors were used along with visual observations of the pilots and ground personnel to rate the effectiveness of each pad in controlling the dust. The CH-46 pilots’ observations and ranking of the 18 helipads is provided in Table 2. The CH-53 pilot’s observations and rankings of the 18 helipads are provided in Table 3. Based on the pilot’s rankings, the [redacted] was clearly noted as the most effective product.

Each helipad was rated using a weighted point system based upon four factors. The resistance to rotor wash was selected as the single most important factor. The resistance to rotor wash was rated from 0 to 10 based upon the amount of dust measured using the dust collectors and visual observations from the pilots. The resistance to rotor wash represents the effectiveness of the palliative in mitigating dust and represents 50% of the overall rating. The durability of the treated helipad was the second factor considered, and it consisted of a rating from 0 to 10 based upon the ability of the product to withstand environmental changes and occasional traffic. The durability factor represents 20% of the final score. The third factor was Foreign Object Debris (FOD) potential, representing 20% of the final rating. The FOD potential was rated from 0 to 10 based upon the observed potential of each product in generating FOD for the operating aircraft, as well as adjacent parked aircraft. Finally, the overall surface condition was rated from 0 to 10 based upon the texture of the surface and the impact on military operations such as refueling operations. Table 4 summarizes the ratings of each helipad tested.

Field Trial 2

A second field evaluation of dust palliatives was conducted from 25 September to 12 October 2005 at MCAS Yuma. The major objectives of this evaluation were to determine minimum application quantities for achieving desired performance and to evaluate previously untested products. In the first field trial, product vendors were allowed to direct the placement of their products. This resulted in a wide range of application rates and methods being used. In the second field trial, ERDC representatives performed the palliative applications using equal volumes of product to compare the relative effectiveness. This evaluation was performed in conjunction with the Weapons and Tactics Instruction (WTI) planned during that time. Rotary-wing aircraft were provided by the Marine Aviation Weapons and Tactics Squadron 1 (MAWTS-1) at MCAS Yuma. The test aircraft included the

UH-1, CH-53, CH-46, and AH-1. Aircraft landings were used to evaluate fifteen helipads constructed with various chemical dust palliatives and application rates.

The field tests were conducted at the same location as the first field trial. The area was graded using a model 143H Caterpillar motor grader to remove all native vegetation, and a John Deere 544J four wheel drive bucket loader was used to backblade the loose sand to create a level and uniform surface prior to applying dust palliatives. Any remaining traces of products from the first field trial were removed during this process.

Each helipad was 150- by 150-ft square with 100-ft untreated transition zones for separation. The size of the helipads in this trial was increased to reduce the amount of dust generated from the perimeter of the helipads and to improve the ability of the ground personnel to assess product performance. Table 5 lists the products and application rates used in this test.

Selected helipads were subjected to landings with UH-1, CH-53, CH-46, and AH-1 rotary-wing aircraft. The landing sequence consisted of one “dust off” procedure and three landings. The “dust off” served to remove any accumulated surface material due to testing adjacent helipads before evaluating the products. Dust particle collection and visual rankings were based on the three subsequent landings and departures. Landings took place 3-7 October 2005. Due to limitations concerning aircraft availability, only selected helipads were evaluated with a particular airframe.

The summary of the pilot’s rankings of the helipads is given in Table 6. The pilot’s viewpoint was considered to give the most accurate perspective on the performance of the dust palliatives. The ground crew was often obscured from evaluating the helipads because of dust clouds generated from the perimeter of the helipads.

Durasoil® was consistently rated the best product during all landing sequences by the pilot and ground crew. [redacted] was considered nearly equivalent in effectiveness, but was not rated higher than Durasoil®. Surtac® was also considered to effectively reduce dust consistently throughout the evaluation period [redacted] performed well during the first day of landings, but failed to be effective with other aircraft. The rapid deterioration of [redacted] performance was attributed to the inability of the chloride salt to retain moisture under the temperature and humidity conditions at the testing site. The polymer emulsions, the powdered polymer, and the emulsified rubber were rated poorly because of the generation of FOD as pieces of the surface crust began to break from the ground and become airborne during landings.

The synthetic fluids were consistently the most effective materials for reducing dust for rotary-wing aircraft. In addition to dust reduction, the soil treated with the synhetic fluids remained soft and unbound. No potential for FOD was observed with these products. The synthetic fluids did not reveal any deterioration with accumulated landings, but any problematic areas could be easily maintained by applying additional palliative to needed areas. This maintenance technique would not be acceptable for film-forming products such as polymer emulsions or others. The synthetic fluids are easy to use and require no mixing of multiple components or dilution with prescribed ratios of water and product. These materials are recommended for use on helipads because of the benefits described above.

The polysaccharide product gave marginal to good performance during the evaluations. It generally mitigated significant quantities of dust but did have some visibility problems during landings. The product became very brittle when it dried. The binding ability of the polysaccharide was very weak and broke under foot traffic. FOD generated during landings consisted of small pieces (less than 10 sq in.) but did exist. Exposure to moisture prevented this problem and made the treated soil soft and reworkable. This observation was made one morning after a night with relatively high humidity in the air. The brittle nature of the treated soil was alleviated and foot traffic only caused depressions in the soil. The durability of the polysaccharide is considered to be minimal in climates with frequent precipitation because it is a water-soluble material and may leach from the soil.

The chloride salt was not effective at mitigating dust for sustained periods of time. The product provided excellent dust abatement after placement, but the performance deteriorated rapidly. The deliquescent material was unable to retain moisture in the climate that was present. Upon drying the chloride salt was unable to mitigate dust on the helipad. This product would only be recommended for helipads with lifespans less than two days.

The polymer emulsions provided excellent adhesion to soil grains and provided a strong network of polymer and soil on the ground surface of the helipads. However, lack of penetration of the emulsions resulted in a thin surface crust that was easily broken and provided a focal point for FOD generation. Large sheets of bonded soil (greater than 1 sq ft) pose risk to the aircraft if they are introduced into the rotor wash. Quantities of diluted polymer emulsions would have to exceed 1gsy in order to provide dust abatement and eliminate FOD potential under soil conditions present at the testing site. In addition, techniques for achieving greater penetration of these products are required. Soil surfaces with a higher bearing capacity would be necessary to obtain favorable results with the quantities of product used.

The powdered polymer performed similarly to the polymer emulsions. This product appeared to have a more flexible surface crust that caused it to break into larger sections. It also achieved less penetration than the polymer emulsions due to its higher viscosity. The dust mitigation ability of the product was excellent, but greater penetration would be necessary to eliminate FOD potential.

The emulsified rubber also exhibited performance similar to the polymer emulsions. Its performance as a dust abatement product was excellent, but the lack of penetration and subsequent FOD generation create concern for use on helipads.

Road Dust Abatement

Field Test 3

The first road dust control exercise was scheduled for 16 through 23 March 2004 in Douglas, AZ. Thirteen products were evaluated during the test. Because the objective of the test was to identify methods for long-term dust control, additional testing was performed at intervals of 30, 60, and 90 days from palliative placement to evaluate effectiveness.

The test site for the field experiment consisted of 3.2 miles of an unpaved road paralleling the border between the U.S. and Mexico. The site was located approximately four miles west of Douglas, AZ, and directly south of the U.S. Borer Patrol, Douglas Station on King's Hwy. Use of the road is predominantly by Border Patrol vehicles, and traffic generally consists of 30 to 60 vehicles per day. The existing road consisted of well-graded gravelly clayey sand with a maximum aggregate size of 3/4 in. and a maximum dry density of 136.8 lb/ft^3. The road was disturbed to a 6-in. depth and graded prior to test section construction. Test sections were 500 ft in length and separated by a minimum 100-ft untreated transition.

Each section was constructed using the same procedure. The water-miscible palliatives were diluted 3:1, and approximately 400 to 500 gal of product were applied to the surface using a distribution bar on a hydroseeder in two passes. Products were mixed into the soil using three passes with the Maxon rotary mixer at a depth of 3 in. Compaction immediately followed the tilling. Two coverages were made with the Ingersoll-Rand 12-ton vibratory compactor. The remaining 400 to 500 gal of product were sprayed onto the compacted surface to seal the section.

Each test section was rated using a weighted point system based upon four factors. The ability of the dust palliative to bind the soil and prevent surface deterioration was rated from 0 to 10 and represents 20 percent of the total score. The visual observations made by the ERDC research team on the ability of the product to reduce dust represent 30 percent of the total rating. The number corresponds to the percentage of dust reduced by the palliative divided by ten. Half of the total product rating is based upon these two visual data determined by ERDC researchers. The other 50 percent of the score is taken from the two dust collecting systems used in this study. Both the ERDC stationary dust collection system and the MRI mobile dust sampler are given 25 percent of the final score. The numbers assigned reflect the percentage reduction of dust collected from the control section. Final ratings are shown in Table 7.

Field Test 4

A second road dust control evaluation was scheduled for 8 through 16 September 2004 at Ft. Leonard Wood (FLW), MO. The FLW Range Control provided a section of unpaved road for use during the test. Eight commercially available products were evaluated during the test. Test sections were constructed using various application rates and application procedures. Additional testing was performed at intervals of approximately 30, 80, and 220 days after placing the palliatives to evaluate the products for long term dust control. Final recommendations are based upon observation of the long-term effectiveness of the applied products at reducing airborne dust.

The specific test sites were located on unpaved roads used extensively by the U.S. Army for training soldiers to operate large military vehicles in convoys. The site is located physiographically in the Salem Plateau section of the Ozark Plateau province in an area of low hills. The existing road was constructed with gravelly silty sand, (SP-SM), having a 3.81 cm (1.5-in.) maximum aggregate size and with 56% passing a No. 4 sieve, 32% passing a No. 40 sieve, and 6% passing a No. 200 sieve. The soil was characterized as being non-plastic.

Dust palliatives were applied using both an admix and a topical procedure. The admix procedure was used in the previously described test in Douglas, AZ. This procedure involved mechanically mixing the palliative in the upper surface of the road material. Application rates were varied in an attempt to identify the minimum material quantity needed for the desired performance. FLW was chosen as the location for this test for two main reasons. First, as a major training facility for equipment operators, FLW offered numerous unpaved roads subjected to frequent traffic. Second, FLW is located in a region that has a temperate climate and receives substantial amounts of precipitation throughout the year. Some of the dust palliatives tested were expected to be susceptible to leaching from the soil with exposure to precipitation.

Dust palliatives were sprayed onto the road surface using an Etnyre asphalt emulsion distributor. For the sections treated with the admix procedure, a TEREX RS-325B soil stabilizer/reclaimer was used to till the surface of the road 5.08 cm (2 in.) and to distribute the products. The road was compacted using a Caterpillar CS-563D 12-ton vibratory roller. Each test section was 183 m (600 ft) long with an average width of 7.6 m (25 ft). The road surface was prewetted to break the surface tension of the soil and allow for product penetration and to increase the moisture content of the soil for compaction. The total product amounts for each section are presented in Table 8.

Data from each of the dust collection systems along with visual observations were analyzed to form subjective opinions on the effectiveness of the 8 dust palliatives monitored during this study. The presence of many variables during testing creates difficulty in accurately quantifying results, and the data must be supported by qualitative observations. The benefits and concerns for each type of chemical evaluated for dust mitigation are discussed below.

The polymer emulsions provided excellent dust mitigation for early periods, but their performance diminished at testing periods of 80 and 220 days after construction. These materials adhere to soil particles and provide bonding. The heavy wheeled and tracked vehicles were able to break the bonds at the road surface and dislodge aggregate though abrasive action. Loose aggregate on the surface provided additional contact surfaces for traffic loads to grind surrounding bonded soil into particle sizes capable of producing dust. Once the soil-polymer matrix is disturbed it cannot be rejuvenated without the addition of more polymer emulsion.

The polysaccharide solution was the least effective material tested. It did not appear to bind soil particles as effectively as the polymer emulsions, and it did not provide moisture retention as effectively as the calcium chloride. The surface of this test section remained more workable than the polymers, and the traffic on the road either did not produce loose aggregate or compacted loose aggregate when it was dislodged. The deterioration of the dust mitigating properties was not considered to occur from the abrasive action of aggregate as it was with the polymer emulsions. The polysaccharide did not provide the necessary cohesion of dust particles to prevent them from escaping the road surface.

The calcium chloride provided the best dust suppression throughout the evaluation. The surface of test sections treated with this product retained a wet appearance characterized by a darker color than surrounding soil. The mechanism of dust mitigation is retention of moisture and the conditions at the test location were ideal for this product. Performance was most likely enhanced by precipitation that occurred prior to the 80 and 220-day evaluations. The moisture on other sections evaporated more rapidly and provided acceptable levels of dust for testing. The calcium chloride did not appear to have a significant reduction in concentration caused by leaching from the road. Tests were not conducted to evaluate the magnitude of this occurrence; however, some collection in drainage water is expected to occur. Additionally, no tests were performed to evaluate the corrosive nature of this chemical and the effect it may have on vehicles traveling roads where it was applied.

The synthetic fluids were very effective for short-term use but did not provide good results during the 80- and 220-day evaluations. These materials remain fluid in the soil and increase its workability. They retain slight adhesive properties and may have been affected by their ability to transfer dust from tires of vehicles entering the test sections from untreated areas. During the 30-day evaluation, it was observed that the ends of the test sections containing the synthetic fluids had a lighter color and contained more dust. Dust may have been tracked onto these sections from adjacent areas, affecting their perceived performance. Neither of the products was visibly distinguishable during the 220-day evaluation.

The calcium chloride was the only product with excellent performance 220 days after construction. All of the other sections would need to be maintained to rejuvenate performance. This procedure would be more effective if the road was graded and compacted to reestablish a smooth surface. Subsequent topical application of the palliatives could be made at reduced quantities to regain effectiveness. Only the synthetic fluids are expected to have complete accumulation of product with additional treatments. Both the polysaccharide and calcium chloride will potentially be dissolved in drainage water, reducing their concentrations over time. Reapplication may be necessary to reach their initial concentrations. The polymer emulsions will remain in the soil, but if the bond between the polymer and soil is broken it cannot be reestablished. Further application of the polymer can help to bind those soil grains that have been removed from the soil-polymer matrix and reestablish the network.

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References

Headquarters, Department of the Army. (1987). “Dust control for roads, airfields, and adjacent areas,” Technical Manual 5-830-3, Washington, D.C.

Rushing, J. F., Harrison, J. A., and Tingle, J. S. (2005). “Evaluation of application methods and products for mitigating dust for lines-of-communication and base camp operations.” Technical Report TR-05-09, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Rushing, J.F., Moore, V.M., and Tingle, J.S. (2006). “Evaluation of Chemical Dust Palliatives for Helipads,” Technical Report TR-06-02, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Rushing, J.F., Moore, V.M., Tingle, J.S., Mason, Q., and McCaffrey, T. (2005). “Dust Abatement Methods for Lines-of-Communication and Base Camps in Temperate Climates,” Technical Report TR-05-23, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Styron, C.R., and Eaves, R.C. (1973). “Investigation of dust control materials,” Miscellaneous Paper S-73-70, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Tingle, J. S., Harrison, A., and Rushing, J. F. (2004). “Evaluation of expedient methods for mitigating dust on helipads,” Technical Report TR-04-10, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

List of Tables

Table 1. Field Trial 1 Application Quantities

Product	Helipad Number (Fig. 6)	Additive Amounts (Gallons)			Application Rate gsy	CH-46 Traffic 21-Jan-04
		Product	Water	Total Applied		
[redacted]	1	400 lbs or 44.4 Gal 4.4 Gal of Emulsion	1646	1694	1.02	0
[redacted]	2	400 lbs or 44.4 Gal 4.4 Gal of Emulsion	1860	1909	1.15	0
[redacted]	3	400 lbs or 44.4 Gal 4.4 Gal of Emulsion	1996	2044	1.23	0
[redacted]	4	400	1200	1600	0.96	3
Soiltac A	5	598	1661	2259	1.36	3
Soiltac B	6	299	532	831	0.50	3
[redacted]	7	400	700	1100	0.66	3
[redacted]	8	275	1000	1275	0.77	0
[redacted]	9	250	600	850	0.51	0
Surtac A	10	200	1400	1600	0.96	3
Surtac B	11	130	870	1000	0.60	4
[redacted]	12	165	665	830	0.50	0
[redacted]	13	475	0	475	0.29	0
[redacted]	14	140	691	831	0.50	0
[redacted]	15	850	0	850	0.51	0
[redacted]	16	240	960	1200	0.72	0
[redacted]	17	70	761	831	0.50	0
Untreated	18	0	0	0	0.00	5
Wet Control	19	0	TBD	TBD	TBD	0
Range of Values:		48.8 to 850	0 to 1996	475 to 2259	0.29 to 1.36	0 to 5

Table 2. CH-46 Pilot Rankings and Observations

Helipad	Palliative	Pilot Ranking	Test Order	Observations
15	[redacted]	1	9	Minor dust, almost nothing; Great visibility.
16	[redacted]	2	5	Better than Helipads 1, 4, and 7.
9	[redacted]	3	12	Minor dust, some flaking.
5	Soiltac A	4	7	Little dust; no problem.
8	[redacted]	5	8	Minor dust.
4	[redacted]	6	3	Better than Helipad 1; better each pass.
7	[redacted]	7	4	Similar to helipad 4; improved each landing.
3	[redacted]	8	10	Dusty.
6	Soiltac B	9	11	Dusty; crust beginning to peel.
13	[redacted]	10	15	Better than 10 and 14; better with each pass.
1	[redacted]	11	2	Slightly better than untreated.
2	[redacted]	12	6	As dusty as Helipad 1; Worst of first 5 tested.
12	[redacted]	13	18	Palliative broke up.
10	Surtac A	14	14	Bad helipad, but better than 14.
11	Surtac B	15	17	Same as 10, progressively worse.
14	[redacted]	16	13	Very dusty, worst helipad so far.
17	[redacted]	17	16	Worse than Helipad 10.
18	Untreated	18	1, 19	Worst helipad, but not as bad as Iraq.

Table 3. CH-53 Pilot Rankings and Observations

Helipad	Palliative	Pilot Ranking	Test Order	Observations
15	[redacted]	1	8	Best overall, good dust control, excellent contrast.
13	[redacted]	2	12	No. 2 of test, good dust control, good color contrast.
4	[redacted]	3	3	Good, very little dust below 30 ft.
2	[redacted]	4	6	Poor until below 20 ft.
5	Soiltac A	5	7	Poor above 25 ft, good below.
7	[redacted]	6	4	Good, very little dust below 30 ft.
9	[redacted]	7	11	Good dust control, but slight break-up.
1	[redacted]	8	2	Good, very little dust below 30 ft.
16	[redacted]	9	5	Significant crust break-up.
3	[redacted]	10	9	Poor compared to others. Dust all the way.
6	Soiltac B	11	10	Poor, significant surface break-up.
8	[redacted]	12	13	Poor to deck, similar to untreated.
18	Untreated	13	1	Light dust compared to Iraq.
10	Surtac A	Not Tested	--	Not tested
11	Surtac B	Not Tested	--	Not tested
12	[redacted]	Not Tested	--	Not tested
14	[redacted]	Not Tested	--	Not tested
17	[redacted]	Not Tested	--	Not tested

Table 4. Field Trial 1 Weighted Palliative Ratings[1]

Helipad	Palliative	Rating Factors				Weighted Rating (Up to 100)
		Rotor Wash Resistance (Rating x 5)	**Palliative Durability (Rating X 2)**	**FOD Potential (Rating X 2)**	**Surface Condition (Rating X 1)**	
15	[redacted]	50	20	20	10	100
13	[redacted]	45	15	20	10	90
4	[redacted]	40	20	15	10	85
5	Soiltac A	40	20	15	10	85
7	[redacted]	40	20	15	10	85
9	[redacted]	40	20	15	10	85
1	[redacted]	35	20	15	7	77
2	[redacted]	35	20	15	7	77
16	[redacted]	40	20	10	7	77
8	[redacted]	30	20	15	10	75
6	Soiltac B	30	15	10	7	62
3	[redacted]	20	20	10	7	57
12	[redacted]	20	10	5	5	40
10	Surtac A	5	5	5	7	22
11	Surtac B	5	5	5	7	22
17	[redacted]	0	0	0	3	3
14	[redacted]	0	0	0	2	2
18	Untreated	0	0	0	0	0

[1] Ratings are based on CH-46 and CH-53 flight tests conducted on 18-19 February 2004 with a cure time of 29 to 31 days.

Table 5
Field Trial 2 Palliative Application Quantities

Product	Helipad	Additive Amounts, gal			Application Rate (gsy)
		Product	Water	Total	
[redacted]	1	225	675	900	0.36
Powdered Soiltac®	2	2,200 lb	1,500	1,500	0.60
[redacted]	3	375	1,125	1,500	0.60
Soiltac®	4	375	1,125	1,500	0.60
Surtac®	5	375	1,125	1,500	0.60
[redacted]	6	1,500	0	1,500	0.60
[redacted]	7	900	0	900	0.36
Powdered Soiltac®	8	1,500 lb	900	900	0.36
Soiltac®	9	225	675	900	0.36
[redacted]	10	375	1,125	1,500	0.60
[redacted]	11	225	575	800	0.32
[redacted]	12	1,375	125	1,500	0.60
Durasoil®	13	900	0	900	0.36
Surtac®	14	225	675	900	0.36
Untreated	15	0	0	0	

Table 6
Field Trial 2 Summary of Pilot's Ranking

Helipad	Product	UH-1	CH-53	CH-46	AH-1
13	Durasoil® (0.36)		1	1	1
7	[redacted] (0.36)		2	2	2
6	[redacted] (0.60)	1	3	3	3
5	Surtac® (0.60)	3		4	4
14	Surtac® (0.36)				5
12	[redacted] (0.60)	2	4	5	
3	[redacted] (0.60)	4			
2	Powdered Soiltac® (0.60)	5			
4	Soiltac® (0.60)	6			
10	[redacted] (0.60)			6	
15	Control	7	5	7	6

Table 7
Field Trial 3 Weighted Palliative Rating

Section	Product	Surface Ravelling (20%)	Visual Dust Rating (30%)	ERDC Dust Reduction (25%)	MRI Dust Reduction -25%	Total
18	[redacted]	9	10	10	10	98
19	Soiltac®	5	8	9	9	79
14	[redacted]	5	8	8	9	77
13	Surtac®	4	7	9	9	74
22	[redacted]	2	8	7	9	68
16	[redacted]	0	6	3	7	43
23	[redacted]	1	5	4	6	42
20	[redacted]	1	4	5	5	39
21	[redacted]	2	4	4	4	36
17	[redacted]	1	5	3	4	35
12	[redacted]	0	4	0	4	22
15	[redacted]	0	2	6	0	21
11	[redacted]	0	3	0	0	9
24	Control	0	2	0	0	6

Table 8. Field Trial 4 Palliative Application Quantities

Section	Palliative	Additive Amounts (Liters)				Application Rate (L/m^2)	Application Procedure
		Product	Dilution Ratio[1]	Water	Total[2]		
1	[redacted]	1325	3:1	3875	5110	3.6	Admix
2	Soiltac	1325	3:1	3875	5110	3.6	Admix
3	[redacted]	1041	3:1	4069	5110	3.6	Admix
4	[redacted]	1325	3:1	3875	5110	3.6	Admix
5	Surtac	1325	3:1	3875	5110	3.6	Admix
6	[redacted]	5110	neat	0	5110	3.6	Admix
7	Durasoil	5110	neat	0	5110	3.6	Admix
8	[redacted]	5110	neat	0	5110	3.6	Admix
9	[redacted]	2555	neat	0	2555	1.8	Topical
10	Durasoil	2555	neat	0	2555	1.8	Topical
11	[redacted]	662	3:1	1987	2650	1.8	Topical
12	Control	0	neat	2555	2555	1.8	Topical
13	[redacted]	662	3:1	1987	2650	1.8	Topical

[1] Approximate dilution ratios. Actual value may be slightly higher or lower.

[2] Total product amount placed in distributor. Approximately 2460 L was used for 1.8 L/m^2 application rate and 4921 L for 3.6 L/m^2 application rate.