

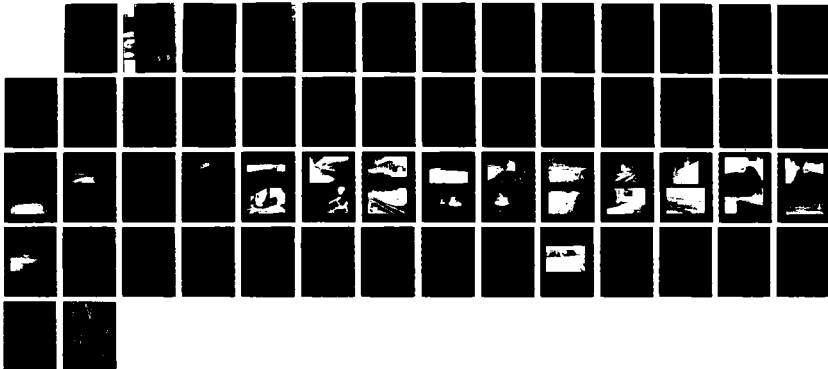
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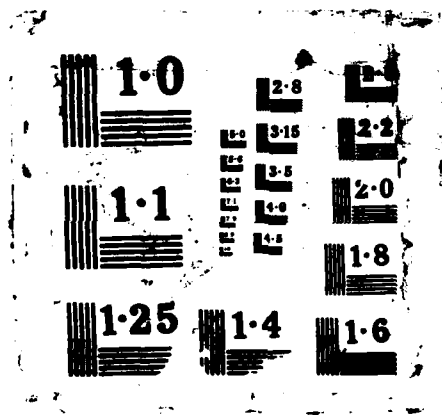
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DUSTPROOFING UNSURFACED AREAS: FACILITIES TECHNOLOGY APPLICATION TEST (FTAT) DEMONSTRATION, FY 86

by

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August 1987

Final Report

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The occurrence of dust as a result of military activities is discussed. Recommended procedures and results of a dust control field demonstration on crushed limestone roads, a cherty gravel parking lot, and a sandy clay assault airstrip are presented. A comparison of two brine solutions, magnesium chloride (MgCl₂) and calcium chloride (CaCl₂), is made with respect to concentration of solution, rate and ease of application, cost, and overall effectiveness on crushed limestone roads. A 32 percent MgCl₂ brine solution was applied at a rate of 0.50 gal/sq yd, and a 38 percent CaCl₂ brine solution was applied at a rate of 0.27 to 0.36 gal/sq yd. The CaCl₂ appeared to penetrate the crushed limestone roads more easily than the MgCl₂, which exhibited ponding and surface runoff. The better penetrating characteristics of CaCl₂ may be attributed to the lower rate of application. Both the MgCl₂ and CaCl₂ were considered equally effective on the crushed limestone roads after a 2-1/2 month review. (Continued)					
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CaCl_2 was also applied to a cherty gravel parking lot and sandy a clay assault airstrip. The parking lot exhibited effective dust control, but the assault airstrip was marginally effective. This is attributed to the higher concentration of fine material in the poorly graded soil. The cost of brine solutions is approximately the same on an F.O.B. basis but may vary considerably based on shipping costs. A cost comparison and a product sheet are included in Appendix C.

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PREFACE

The Office, Chief of Engineers (OCE), US Army, sponsored this study as a part of the O&MA Program, Facilities Technology Application Tests (FTAT), Demonstration Program FY 86. The OCE Technical Monitor was Mr. R. W. Williams.

The study was conducted under the general supervision of Dr. W. F. Marcuson III, Chief, Geotechnical Laboratory, and under the direct supervision of Messrs. H. H. Ulery, Jr., Chief, Pavement Systems Division (PSD); H. L. Green, Chief, Engineering Analysis Group, PSD; and R. H. Grau, Material Development Unit, PSD. The US Army Engineer Waterways Experiment Station (WES) FTAT project managers during the course of this demonstration were MAJ R. A. Hass and Mr. R. C. Ahlrich, PSD. Messrs. T. P. Williams and J. P. Armstrong, PSD; J. Warwicke, Information Products Division (IPD), Information Technology Laboratory (ITL); D. R. Haulman, Engineering and Construction Services Division; and J. W. Turner III, Procurement and Supply Office, provided field test support. Delivery and application of materials were contracted to W. W. Sales and Leasing Co. of Edwardsville, Ill. This report was prepared by Mr. Armstrong. Ms. Odell F. Allen, IPD, ITL, edited the report.

Messrs. W. Adams and R. Stephens, Directorate of Engineering and Housing provided installation support during the period 26 May to 7 June 1986 at Fort Campbell, Ky.

COL Dwayne G. Lee, CE, was Commander and Director of WES during the preparation and publication of this report. Dr. Robert W. Whalin was Technical Director.



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**CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT**

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
degrees (angle)	0.01745329	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
feet	0.3048	metres
gallons per square yard	4.5273	cubic decimetres per square metre
gallons (US liquid)	3.785412	cubic decimetres
inches	2.54	centimetres
miles (US statute)	1.609347	kilometres
square yards	0.8361274	square metres
tons (2,000 pounds, mass)	907.1847	kilograms

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use $K = (5/9)(F - 32) + 273.15$.

DUSTPROOFING UNSURFACED AREAS: FACILITIES TECHNOLOGY
APPLICATION TEST (FTAT) DEMONSTRATION, FY 86

PART I: INTRODUCTION

Background

1. In 1983 the Director of Research and Development, Office, Chief of Engineers, US Army, requested the Waterways Experiment Station (WES) to demonstrate the procedures and techniques for dustproofing unsurfaced roads and areas on military installations.

2. WES has previously conducted intensive research, field experiments, and evaluations of hundreds of dust control agents and palliatives along with numerous dustproofing techniques and procedures (Styron and Eaves 1973). The culmination of this research and development in the area of dustproofing is technology transfer under the guidance of the Facilities Technology Application Test (FTAT) Demonstration Program.

3. This is the final report in a series of three dedicated to technology transfer on the subject of dustproofing. The first report provided data concerning dustproofing demonstrations held at Fort Bliss, Tex., and Fort Stewart, Ga. (Styron, Hass, and Kelly 1985), in which a magnesium chloride ($MgCl_2$) brine solution was used on tank trails and polyvinyl acetate was used on lightly traveled areas. The second report provided data concerning dustproofing demonstrations held at Fort Irwin, Calif., and Fort Chaffee, Ark. (Hass 1986), in which $MgCl_2$ was used on silty sand roads, maintenance and bivouac areas, and a gravelly sandy clay assault airstrip.

Occurrence

4. Dust has been a longtime enemy of the Army, especially in a tactical scenario. It occurs wherever military equipment operates over dry, unsurfaced terrain. This dust occurs when the small surface particles of the soil are scraped or rubbed away from the traveled surface by vehicle tires and tracks (Figure 1) or aircraft landing gear and prop wash (Figure 2) and then

carried airborne by wind forces.* One vehicle crossing an open field will not usually produce an objectionable amount of dust. However, the large, blinding, fog-like clouds occur when many vehicles follow the same unsurfaced route or when numerous aircraft sorties use the same unsurfaced airstrip (Figure 3). A good structural material for gravel roads and assault airstrips is a coarse aggregate with sufficient sand to fill the voids and adequate fines to bind these materials together. Abrasion of the small soil particles begins with the passage of the first vehicle on the unsurfaced area. Gradually as more and more vehicles or aircraft pass over the unsurfaced area, sufficient small soil particles are displaced so that the larger soil particles become unstable. Ruts, potholes, and washboard begin to form, and soon maintenance will be required to reduce the severity and extent of deterioration. If sufficient fine soil particles are not replaced to stabilize the larger particles, the time between succeeding maintenance periods will be reduced, and annual maintenance cost will increase. A good dust control material resists the abrasion of the small soil particles, and a more stable condition is realized over a longer time period.

Plan of Demonstration

5. One of the dust control techniques developed for dustproofing unsurfaced areas is the use of hygroscopic surface penetrants, such as a brine solution, as a dust palliative. Two brine solutions of deliquescent compounds, Magnesium Chloride ($MgCl_2$) and Calcium Chloride ($CaCl_2$), were tested. Their performances were compared at Fort Campbell, Ky. This installation was chosen based upon dust control need, varying terrain and soil type, weather conditions, and location. The materials were applied to crushed limestone surfaced roads, a cherty gravel parking lot, and a sandy clay assault airstrip.

6. The selection of both $MgCl_2$ and $CaCl_2$ was made to compare the effectiveness and ease of application of the two products. Both products have hygroscopic properties which bind the fine soil particles (dust) to the larger soil particles by absorbing moisture from the air. The surface produced is a

* In wet weather, the same abraded particles are washed away in the form of mud.

tight, macadam-like surface when compacted. Brine solutions are most effective when utilized on cohesionless soils.

7. Demonstration sites were selected, prepared, and treated at Fort Campbell. Each site was bladed to remove ruts, potholes, washboard, and all loose material. Compaction was necessary only at the assault airstrip. Prewetting was performed as necessary (the $MgCl_2$ producer specifies prewetting while $CaCl_2$ producer does not) to reduce surface tension, and then the dust palliatives were applied. Fort Campbell Directorate of Engineering and Housing (DEH) personnel performed blading and compaction operations while a contractor performed the prewetting and application of dust palliatives to designated sites. The contractor used a tractor with a modified 4,000-gal liquid tanker trailer to spread the materials.

PART II: DEMONSTRATION

Site Selection

8. Fort Campbell, Ky., was selected for the FY 86 FTAT demonstration site. WES Engineers visited Fort Campbell in October of 1985 to ensure that there was a need for dust control and that adequate support was available for conducting a dustproofing demonstration. Site inspection indicated a considerable amount of dust being generated on crushed limestone surfaced roads and a cherty gravel parking lot. In addition, a sandy clay assault airstrip was selected, although the soil type is not considered to be favorable for surface penetrant application.

Coordination

9. Approval for use of Fort Campbell was made through the Office of the Commander, Headquarters, 101st Airborne Division (Air Assault) and Fort Campbell. DEH personnel arranged to have soil samples taken from designated areas and shipped to WES for testing in November 1985. They also assigned installation personnel to the demonstration areas to conduct site preparation, blading with motor graders, and rolling operations. The Range Control Office was contacted to ensure that access to demonstration sites would be possible. A contractor, W. W. Sales and Leasing Co. of Edwardsville, Ill., was awarded a contract to deliver, prewet, and distribute dust palliatives. Arrangements were made to perform the dustproofing demonstration between 26 May and 7 June 1986 (see Appendix A for dustproofing procedure synopsis and demonstration plan).

Logistics

10. Delivery arrangements were made with the contractor for the $MgCl_2$ and $CaCl_2$ to be transported to the demonstration sites. The $CaCl_2$ was delivered in seventeen 4,000 gal* liquid tanker trailer loads, and the $MgCl_2$ was

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

delivered in two 18,000 gal super tanker railroad cars. Arrangements were made with the Fort Campbell Rail Service to have the tankers delivered and stored at a convenient railhead siting. A photographer, a technician, and labor were scheduled for the designated demonstration time. Notification of the demonstration was sent to all Major Army Commands to inform individuals of the date, time, and location of the demonstration. Handouts, demonstration plans, and briefings were prepared for interested individuals.

PART III: PROJECT PROCEDURE

Objective

11. The main objective of this and previous dust control demonstrations is to familiarize the DEH community with the new technology by providing firsthand experience through observation, either by onsite or videotape viewing of dustproofing techniques and procedures.

Examples of Dust Problems

12. A few examples of dust-control problems that occur on military installations where dustproofing techniques should be considered for implementation are as follows:

- a. Dust generated by military vehicles operating on unsurfaced tank trails intrudes into housing areas or commercial activities that are adjacent to these tank trails.
- b. Dust from tank trails impairs visibility on adjacent highways, roads, and streets.
- c. Dust clouds generated by military vehicles operating on tank trails impair the visibility of military vehicle operators while driving on the tank trails.
- d. Dust clouds generated by military aircraft operating on unsurfaced airstrips or helipads reduce the safe operations of the aircraft in those areas.
- e. Dust intrudes into engines, engine compartments, air filtering systems, vehicle/aircraft turbines, and vehicle/aircraft cargo areas which increases wear and tear on the vehicles and aircraft.
- f. Dust irritates the lungs and eyes of soldiers operating military vehicles.
- g. Dust clouds generated by military aircraft or vehicle operations provide a recognizable signature to enemy forces in a tactical situation.

Construction Method Recommended

13. The area to be treated is bladed with a motor grader to remove all loose material, ruts, potholes, and washboard. Compaction of the bladed surface with a pneumatic rubber-tired roller to achieve a hard surface is

suggested if it appears that normal traffic is unable to provide adequate compaction. Prewetting with water is recommended to reduce surface tension, to allow maximum penetration of the dust-control agent, and to ensure uniform application of the dust-control liquid over the applied area. The amount of water utilized during the prewetting operation ranges between 0.03 and 0.30 gal/sq yd, but is dependent upon surface conditions, soil type, and prevailing weather conditions. (The manufacturer of $MgCl_2$ strongly recommends prewetting of any soil type prior to application of $MgCl_2$. The manufacturer of $CaCl_2$ states that prewetting is not necessary prior to application of $CaCl_2$ because of its inherent penetrating capabilities.) If prewetting is performed, any water that has ponded should be broomed or swept away before application of the dust control material.

14. The dust-control material is applied as a liquid. Most dust control liquids can be applied with a common asphalt distributor, gravity-fed water truck, or any transportable liquid container tank with an external pump and spray bar or spray hose. Agitation during transport and application helps to prevent segregation of the solution. Application rates for dust-control liquids depend on the concentration of effective ingredient and viscosity (or penetrating properties). First time application rates of brine solutions are generally higher than follow-up application rates because of residual effects.

15. Close attention should be given to location of the spray bar or spray hose to ensure that a 6- to 12-in. overlap is maintained on previously treated strips. It is important to ensure that the selected areas are not too dry from too little prewetting or evaporation of the water; otherwise the dust-control material will not penetrate the surface area, and total coverage will not be achieved. The discontinuity of the dust control material on the surface area and subsequent untreated areas are called fisheyes. Application operations should be terminated whenever fisheyes occur, and additional water should be applied before applying any more dust control material.

16. Treated areas are allowed to cure following application of dust control materials. Curing generally takes between 0 to 4 hr depending on soil type and weather conditions. The degree of effectiveness sacrificed is directly attributed to the actual cure time allowed in contrast to the actual cure time necessary.

Materials Required

17. Dust-control materials selected for the FY 86 demonstration were $MgCl_2$ and $CaCl_2$. Appendix B contains chemical analyses of several brine solutions including those used at Fort Campbell. Tests performed at WES indicated that $MgCl_2$ had the potential for adequate dust control during a finite period when applied to stone/gravel roads or areas having cohesionless type soil surfaces which are subjected to different types of vehicular traffic (Styron and Spivey 1982). Chemical analysis of $CaCl_2$ and its previous usage in dust control and soil stabilization operations indicated that it may have dust control properties similar to $MgCl_2$. Therefore $CaCl_2$ was chosen to compare application techniques and performance to those of $MgCl_2$.

18. Both materials are applied as received from supplier with no dilution required. Application rate of $MgCl_2$ ranges from 0.42 to 0.50 gal/sq yd for 32 percent $MgCl_2$ solution. Application rate of $CaCl_2$ ranges from 0.27 to 0.36 gal/sq yd for 38 percent $CaCl_2$ solution. Solutions of both materials are no more corrosive than plain water provided there is no air present. When a metal surface is wet with these solutions or the solution is strongly aerated, rusting will occur. The same effect will occur if water were used instead of the chloride solutions. Normally, films of water will evaporate to dryness, stopping the corrosion process. Brine solutions will continue to absorb moisture from the atmosphere, and corrosion can continue over a longer period of time than if plain water were used. Vehicles or aircraft that come in contact with treated areas should be washed during normal after-operation preventive maintenance periods. Personnel who come in contact with either brine solution should follow basic hygiene practices. If either material is to be used for dust control, the installer should request the appropriate material safety data sheet (OSHA form 20) from the manufacturer, and project personnel should be familiar with the contents.

Equipment Required

19. A motor grader is needed to blade the area to be treated, and a pneumatic rubber-tired roller and a steel-wheeled roller may be required to compact the bladed surface. A water truck or other liquid carrying transport unit with distribution equipment is utilized to prewet and/or apply brine

solution dust palliative. Since brine solutions are not natural lubricants, providing an external lubrication system for certain types of pumps, such as that on an asphalt distributor, may be necessary.

20. A misconception that is commonly encountered in dustproofing operations is that several men and several pieces of equipment are always necessary. If the area to be treated (such as a gravel road) is in relatively good condition (free of ruts, washboarding, and potholes), prewetting (in the case of $MgCl_2$, unless it has just rained) and applying the dust palliative, followed by compaction from normal traffic are the only necessities.

Personnel Required

21. Experienced operators are required for equipment to be used. A civil engineer, an engineering technician, or an equipment foreman who is familiar with dust-control operations should be present when dust-control material is being placed.

22. Appendix A provides a synopsis of dustproofing procedure with brine solutions and a specific demonstration plan developed for the Fort Campbell dustproofing demonstration.

PART IV: CONDUCT OF DEMONSTRATION

23. Fort Campbell, Ky., home of the 101st Airborne Division, was selected as the FY 86 demonstration site (see Part II: Demonstration). The DEH at Fort Campbell was responsible for project site preparation and equipment availability. The WES was responsible for contracting for material delivery and application and for specifying application procedures.

24. During 26 May to 7 June 1986, personnel from the WES, DEH at Fort Campbell, and W. W. Sales and Leasing Co. (contractor) worked together to conduct the FTAT FY 86 dustproofing demonstration. Soil samples were taken in November 1985, and sieve analysis was performed in January 1986. Technical Manual TM 5-830-3/AFM 88-17, Chap. 3 provides tables for evaluating dust palliative requirements for various soil types (Headquarters, Departments of the Army and the Air Force 1974 (currently being revised)).

25. Gradation curves were plotted from sieve analysis of samples taken from the top 6 in. of areas to be treated. Atterberg Limits were determined for material passing the No. 40 sieve, and each sample was classified in accordance with the Unified Soil Classification System (USCS). Typical classifications were: crushed limestone from unsurfaced roads is a light gray silty gravel with sand (GP-GM); cherty gravel from parking lot is a reddish brown sandy clayey gravel (GC); sandy clay material from the assault airstrip is a tan sandy clay (CL). Gradation curves are shown in Figures 4 to 6. Tables 4-2 and 4-3 of Dust Control TM 5-830-3/AFM 88-17, Chap. 3 (currently under revision) indicate that the road and parking lot material are very suitable for brine solution application. The airfield material, however, is only marginally suitable for brine solution application.

26. The surface penetration method was demonstrated using CaCl_2 (38 percent solution at 77° F) and MgCl_2 (32 percent solution at 77° F). Both materials are hygroscopic in nature (i.e., readily take up and retain moisture), and both cause the finer grained, dust generating material (passing No. 200 sieve) to adhere to the coarser grained material. A contract was let to deliver and spread dustproofing materials. Field modifications were made necessary to area B since a bridge had been dismantled by troops on West Perimeter Road (see Figure 7 and Appendix A). Modifications are further described in paragraph 28.

27. WES personnel arrived in the Fort Campbell area on the evening of 26 May. Application of dustproofing materials was scheduled to begin on 27 May, but heavy rain forecasts and the fact that blading of roads had not been accomplished resulted in a 1-day delay. All roads were bladed on the afternoon of 27 May and the morning of 28 May (Figure 8). Two 4,000-gal spreader trucks arrived at 11:00 a.m. on 28 May and began applying CaCl_2 on area D. Prior to application, displacement pumps were calibrated (Figure 9) at 2,000 rpm to coincide with application rates for varying spray bar widths at given speeds in feet per minute (Figure 10). A quality assurance check was performed on CaCl_2 by measuring the specific gravity and temperature in a graduated cylinder (Figure 11). Specific gravity was determined to be 1.385 at 75° F which is satisfactory for 38 percent solution CaCl_2 . Spreader trucks were reloaded from 4,000-gal transport trucks as shown in Figure 12. Figure 13 depicts the two spreader trucks working together.

28. Because of the removal of a bridge on West Perimeter Road, only 4 miles of the scheduled 10 miles of area B were treated. The extra allotted material was spread on Big Rock Road and portions of Jordan Springs, Artillery, and Patton Roads. Table 1 describes application procedures for the areas that were actually treated during this demonstration.

29. One of the spreaders was released on the evening of 28 May since it did not appear that the workload warranted two spreaders. Daily rains prevented work on the sandy clay assault airstrip, and the railroad tank cars with MgCl_2 had not arrived. Areas B and D were completed the afternoon of 29 May.

30. Based on the daily rains and weather forecast for the weekend, blading and rolling of the airfield were delayed until Monday, 2 June. However, on Sunday, 1 June, the airfield was dry; and 11 sorties were performed by C-130 aircraft of the 317th Air Force Wing from Pope AFB, North Carolina. Figure 14 shows dust generated by a landing aircraft, and Figure 2 shows the height of dust billow near the southwest end of the runway. Dust clouds took from 1 to 5 min to dissipate.

31. There was some rain on the evening of 1 June, but the airfield was dry enough by 10:30 a.m. of 2 June to permit blading and rolling (see Figures 15-17). On 3 June, 8-ft-wide test strips located on the runway shoulder were treated with CaCl_2 at a rate of 0.175 gal/sq yd. Although the CaCl_2 penetrated well in areas that were well compacted, the treated material would

ball up in loosely consolidated areas (Figure 18). It also appeared that it was not feasible to apply the material in two light coats on the airstrip since the treated fine-grained material would not cure fast enough to sustain traffic for the second application (Figure 19). A prewetting effort of 0.20 to 0.25 gal/sq yd was followed by a single pass with an 18-ft spray bar applying CaCl_2 at a rate of 0.35 gal/sq yd (Figure 20). All prewetting and CaCl_2 applications of the airfield were completed by 5:30 p.m. after having started at approximately 9:00 a.m. Total area treated was 3,900 by 100 ft plus taxi area. Heavy rains forced the cancellation of the C-130 sorties that were scheduled for the airstrip on Wednesday, 4 June.

32. The MgCl_2 finally arrived late Thursday, 5 June, but was not spotted at a workable rail siding until 9:30 a.m., 6 June. The spreader truck intake hose was connected to the bottom of the railroad tank cars with the use of two 36-in. pipe wrenches and an extension bar or "cheater" bar (Figure 21). By 11:00 a.m. the first load was ready to spread. Tests for specific gravity indicated an acceptable 1.30 at 74° F. A 90-min turnaround time was required for each load. The crew was able to spread four loads and to fill up a fifth load before ceasing work for the day. The fifth through eighth loads were taken from the second railroad car which had a stuck exhaust valve. This required that the material be pumped out of the top of the railroad car (Figure 22). Spreading of MgCl_2 on the northern portion of Patton Road was completed by noon on 7 June. The fact that the MgCl_2 did not appear to penetrate as well as the CaCl_2 did on the crushed-limestone roads is noteworthy. This could be attributed to several factors including the saturated condition of roads because of heavy rains and higher application rate at only one pass (see Table 1). Figure 23 depicts typical surface runoff to road shoulders.

33. In all, 67,820 gal of CaCl_2 and 36,000 gal of MgCl_2 were applied at Fort Campbell. During the course of the project, four motor grader operators, two tractor trailer operators, and two roller operators were utilized, but the workload could easily have been achieved over the 2-week work period with one-half the personnel. Original plans had scheduled the work to be completed in 3-1/2 days. Inclement weather and late arrival of the railroad tanker cars extended the project to 12 days. Actual work was performed in 4-1/2 days.

34. Crushed-limestone roads treated with CaCl_2 and MgCl_2 displayed 100 percent dust elimination after initial treatment. A visual inspection of the gravel roads was made 2 months later on 18 July 1986, and dust abatement

was found to be 85 to 95 percent effective (qualitatively speaking). The areas on Patton Road treated with $MgCl_2$ and $CaCl_2$ appeared to have equivalent effectiveness. Figures 24 and 25 depict the effect of one car being driven between treated and untreated areas. Figure 26 shows a car traveling on a completely treated road.

35. Arrangements had been made with the 118th Tactical Air Wing of Nashville, Tenn., to land a C-130 aircraft on the assault airstrip during our visit. Landings indicate that the volume of dust generated was less than that of the 1 June 1986 landings and that dust settled much more quickly. However, the volume of dust still left an easily recognizable signature of military operations (see Figure 27). If landings had been attempted directly after placement, the hypothesis is that the results would be more like that found in FTAT FY 85 (see Figure 28). CPT Burton Fuqua, who piloted four sorties with the C-130, stated that during landings, the propeller blades are reversed until speed is reduced to 60 knots after which the propellers are brought out of reverse and the presence of dust is usually quite noticeable. CPT Fuqua stated that there was little dust noticed on the first two landings but that it increased on the third and fourth landings. Turnaround time between sorties was approximately 10 min. The volume of dust generated is attributed to the marginally acceptable nature (with respect to dust control method) of the tan sandy clay airstrip material.

PART V: ECONOMICS

36. A fact sheet was developed for the products used in the dustproofing demonstration. It is included in Appendix C along with a breakdown of typical material, delivery, and application costs.

37. The total cost of material, delivery, preparation, and application of brine solutions varied for CaCl_2 and MgCl_2 because of shipping. Shipping costs vary due to location. Bid price for CaCl_2 was \$0.6194/gal or a range of \$0.1672 to \$0.2230/sq yd applied (0.27 to 0.36 gal/sq yd). Bid price for MgCl_2 was \$0.7264/gal or \$0.3051 to \$0.3632/sq yd applied (0.42 to 0.50 gal/sq yd).

38. The products performed in a similar fashion and are known to be most effective on a cohesionless, well-graded (sand and gravel) soil. They are not effective on totally fine-grained soils. Leaching of product occurs in areas of excessive rain. Areas with low humidity (less than 30 percent) require rejuvenation with water. The design life of brine solutions is 8 to 12 months. The design life may be increased with successive treatments of 50 percent of normal treatment.

PART VI: ADVANTAGES AND DISADVANTAGES

39. Reduction in the migration of the fine materials in the surface of an unsurfaced pavement (i.e., controlling dust) will reduce the formation of ruts caused when sufficient fines are displaced to render the larger particles unstable. By limiting the instability of the fine material and postponing the formation of ruts, the need for blading and compacting is substantially decreased resulting in lower maintenance costs. Actual dollar savings will vary with location and weather extremes. During a previous demonstration project utilizing $MgCl_2$, blading of the treated project site was reduced from 12 to 4 times a year at the installation (Styron, Hass, and Kelley 1985).

40. Brine solutions have received limited evaluation as to their environmental influence. The practice of spraying the material with a spray bar height of 6 to 10 in. above the roadway and ensuring the material is sprayed only on the roadbed with no runoff permitted provides an environmentally acceptable procedure and product. $MgCl_2$ is known to leach out of the treated material with time; however, a long time and considerable rainfall are required (Styron and Spivey 1982, Houston 1983).

41. A dustproofing material is selected depending on cost, type of traffic, soil type, and weather extremes. The material is applied at a rate that avoids all runoff and that does not exceed specifications. Maintenance or additional applications are scheduled as required, depending on actual use and existing weather conditions. A combined Army and Air Force dust control manual exists for assistance in selecting and applying a dustproofing material (Headquarters, Departments of the Army and the Air Force 1974).

42. Brine solutions provide a finite period of dust control on unsurfaced pavement structures which improves vehicle operator safety and aircraft landing visibility, and which increases flight operations and decreases the dust signature of vehicles and aircraft.

PART VIII: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

43. The brine solutions are not recommended for fine-grained soils (silts and clays) since their effectiveness does not last as long as on coarse-grained soils. The marginally acceptable materials on the assault airstrip treated with CaCl_2 demonstrated a reduction in dust generation at the time of their review, 2 months after application. However, the dust abatement was less than expected.

44. The brine solutions are strongly recommended for well graded cohesionless soils (sand and gravel) with moderate traffic. Both MgCl_2 and CaCl_2 were able to provide a high degree of dust suppression on the crushed-limestone-surfaced roads. The performance of the products may improve if they are applied in two light applications (i.e., "spray painted") rather than one heavy application. Heavy overlapping of single pass applications may be appropriate for narrow roads since most wheeled traffic is in the center of the road and material may migrate to the shoulders over a period of time.

45. The use of a 4,000-gal distributor permitted rapid distribution of the brine solutions. Labor costs were minimized, and there was a minimum of interference with military maneuvers.

46. MgCl_2 and CaCl_2 are also manufactured in the dry form (pellet or flake). In the dry form they have been used in the northern United States as a road de-icer. This dry form may be an acceptable bulk material for dust control if applied on unsurfaced roads like a fertilizer and over-sprayed with water. In addition, the dry form would be easier to transport to distant, isolated locations, and it could be placed in dry form or mixed with water to desired concentration.

Recommendations

47. Four key recommendations needed for future studies have been identified:

- a. Determine the net result of brine solutions in the reduction of wear and tear on vehicles.

- b. Quantify the decreased vehicle signatures utilizing brine solutions at various rates on various soil types.
- c. Determine the procedure and application of dust control materials in dry form.
- d. Determine the benefit to cost ratio for tangible and intangible benefits (i.e., maintenance, regravelling, morale, and safety) that could be derived from using brine solutions on unsurfaced areas.
- e. Determine the corrosive effects of assault runways treated with brine solutions on military aircraft.

48. For further information contact:

USAE Waterways Experiment Station
ATTN: Jeff Armstrong/GP-EM
PO Box 631
Vicksburg, MS 39180-0631

REFERENCES

Hass, R. A. 1986 (Dec). "Dustproofing Unsurfaced Areas: Facilities Technology Application Test (FTAT) Demonstration, FY 85," Technical Report GL-86-20, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

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Houston, T. D., Jr. 1983 (Jul). "In Place Performance Test, Evaluation Studies, Investigation of Magnesium Chloride for Dust Control," Technical Report V2 0092-2-J, Directorate of Engineering and Housing, Fort Stewart, Ga.

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Styron, C. R., III, and Spivey, A. C., Jr. 1982 (Sep). "MX Road Design Criteria Studies; Report 2, Investigation of a Proprietary Material for Dust Control," Technical Report GL-82-11, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Styron, C. R., III, Hass, Robert A., and Kelley, Karen. 1985 (Sep). "Dustproofing Unsurfaced Areas; Facilities Technology Application Test Demonstrations, FY 84," Technical Report GL-85-11, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Table 1

Tabulation of Materials, Application Rates, and Areas for Demonstration Sites

Demonstration Site		Material	Total Area	Application Rate and Number of Passes
Area*	Location			
A	"Heavy Beast" Assault Airstrip at Woodlawn and Centerline Road	17,270 gal of CaCl_2 with prewetting	3,900- by 100-ft air- strip plus 350- by 150-ft taxi area	0.35 gal/sq yd in one pass; prewet 0.25 gal/ sq yd with water
B	West Perimeter Road	15,200 gal of CaCl_2 with no prewetting except rain	4 miles by 24 ft	0.27 gal/sq yd in two passes (i.e., $2 \times 0.135 = 0.27$)
B	Jordan Springs Road	9,000 gal of CaCl_2 with no prewetting except rain	4 miles by 18 ft	0.27 gal/sq yd in two overlapping passes
B	Big Rock Road	7,100 gal of CaCl_2 with no prewetting except rain	2.25 miles by 20 ft	0.27 gal/sq yd in two overlapping passes
B	Artillery Road	3,400 gal of CaCl_2 with no prewetting except rain	0.8 miles by 20 ft	0.36 gal/sq yd in two overlapping passes (i.e., $2 \times 0.18 = 0.36$)
B	Southern portion of Patton Road	8,000 gal of CaCl_2 with no prewetting except rain	1.9 miles by 20 ft	0.36 gal/sq yd in two overlapping passes
C	Northern portion of Patton Road	36,000 gal of MgCl_2 with no prewetting except rain	5.6 miles by 18-24 ft	0.50 gal/sq yd in one pass
D	Indian Mound Road and recreation and parking lot	7,850 gal of CaCl_2 with no prewetting except rain	2 miles by 24 ft plus 250- by 60-ft parking lot	0.27 gal/sq yd in two passes

* Areas are shown in Figure 7.



Figure 1. Armored Personnel Carriers generating dust



Figure 2. C-130 aircraft generating dust

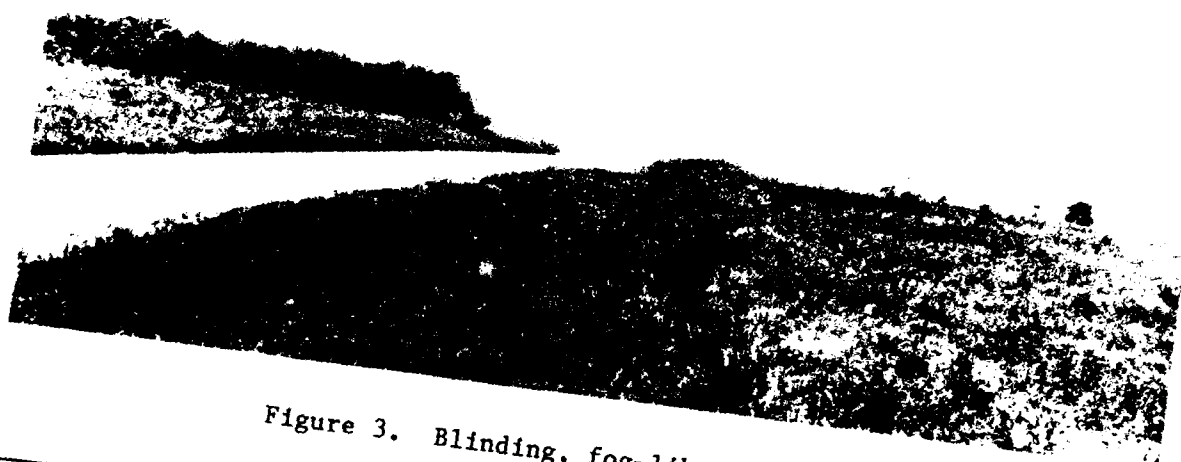


Figure 3. Blinding, fog-like dust cloud

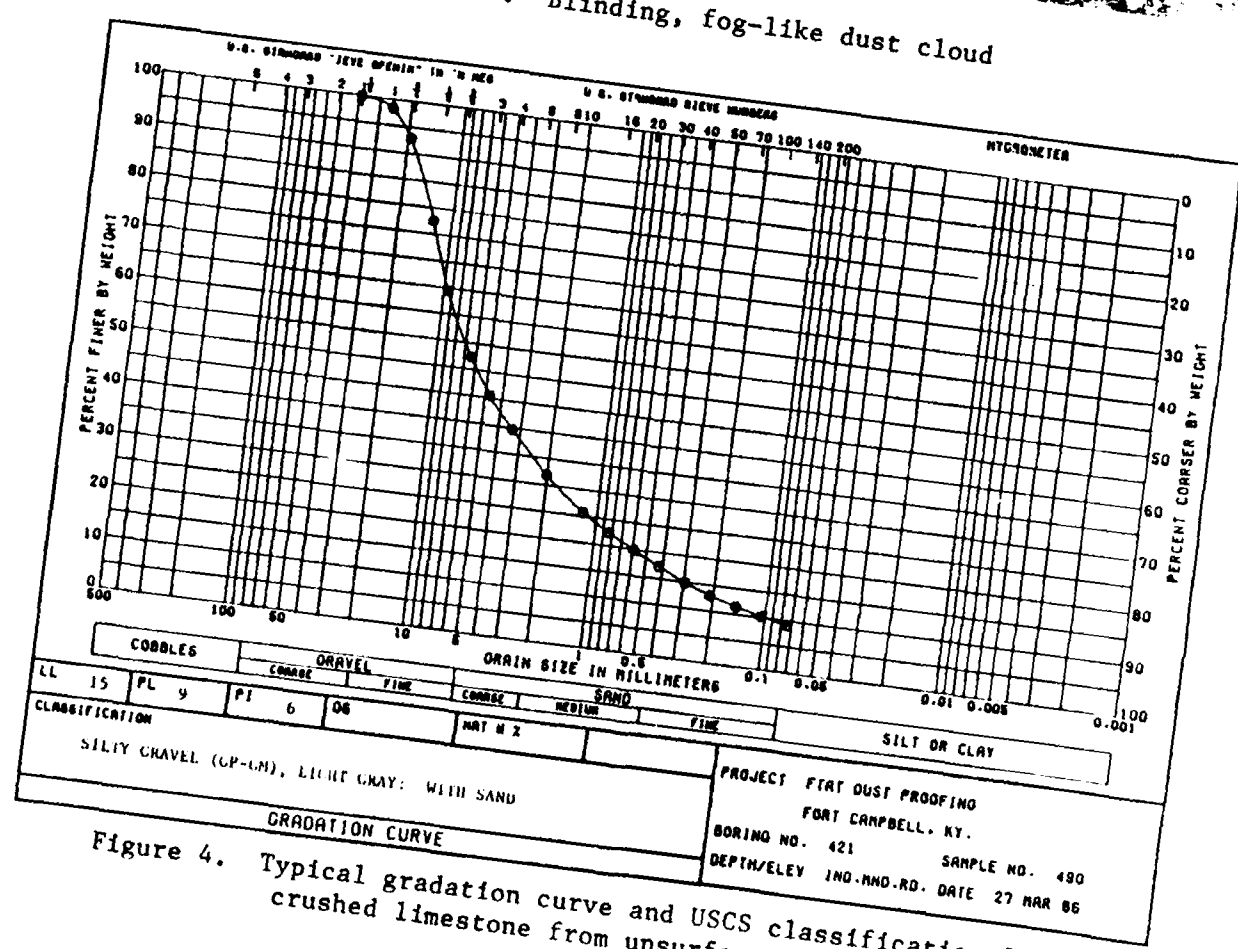


Figure 4. Typical gradation curve and USCS classification for crushed limestone from unsurfaced roads

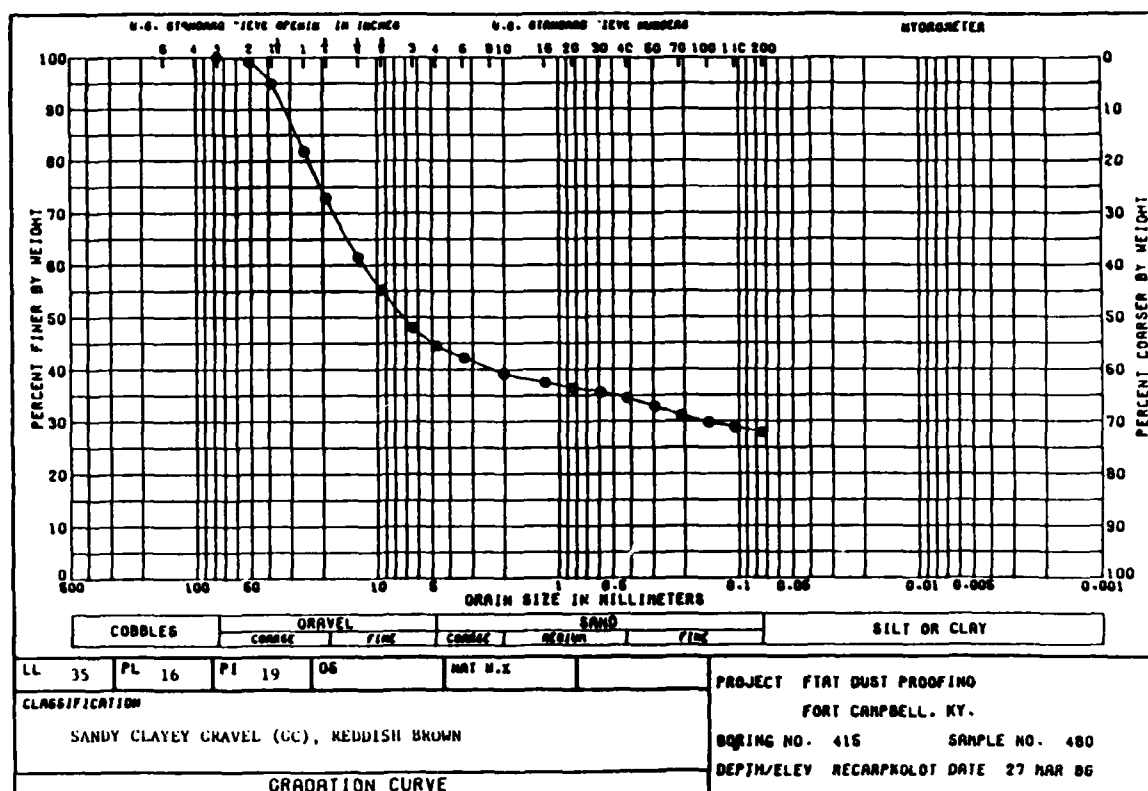


Figure 5. Typical gradation curve and USCS classification for cherty gravel from parking lot

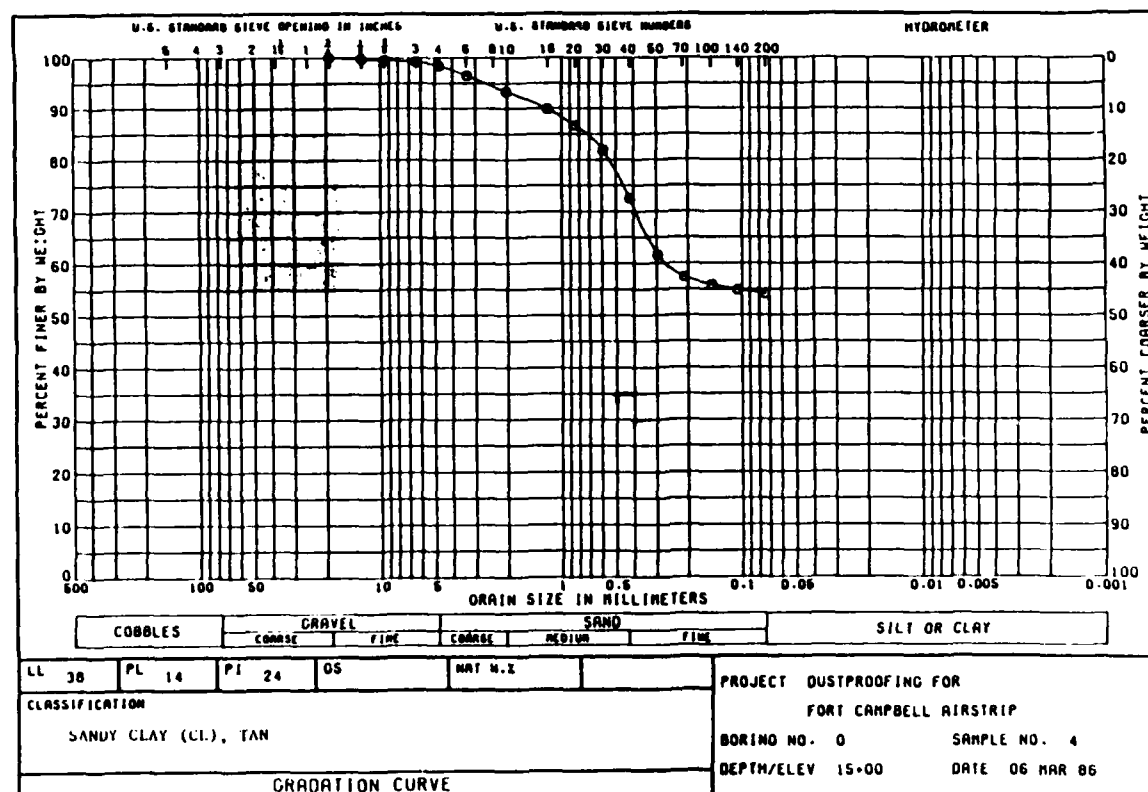


Figure 6. Typical gradation curve and USCS classification for material from assault airstrip

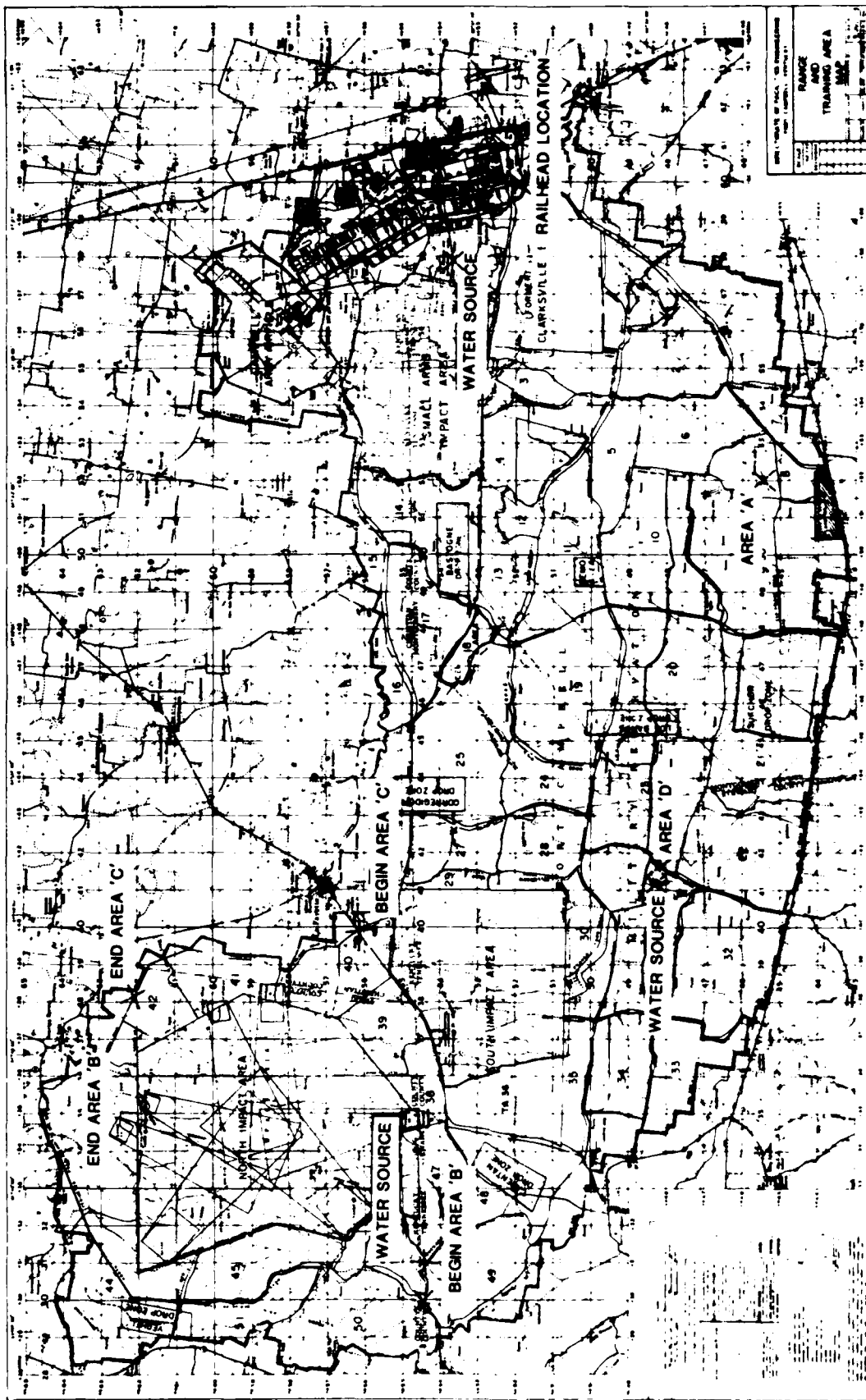


Figure 7. Map of demonstration sites



Figure 8. Blading of roads with motor graders

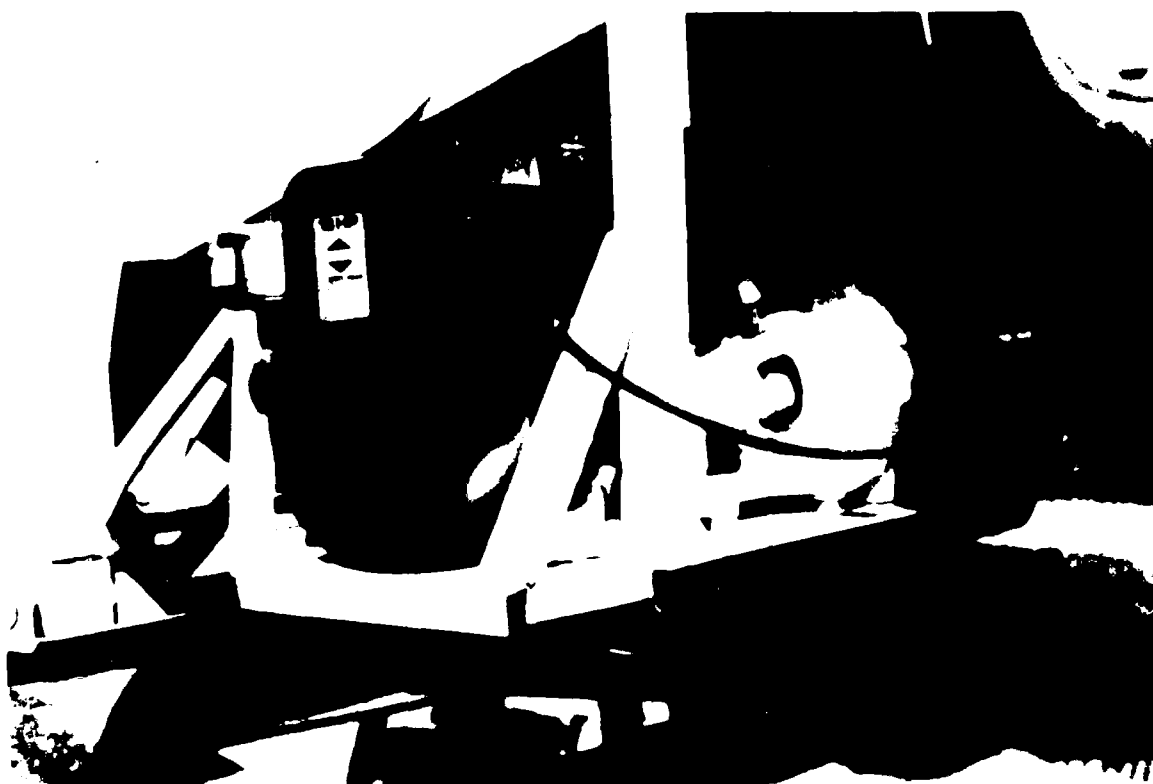


Figure 9. Calibrated, externally-mounted, positive displacement pump



Figure 10. Application of brine solution with adjustable spray bar



Figure 11. Measurement of specific gravity and temperature of CaCl_2 in a graduated cylinder



Figure 12. Loading spreader truck from transport truck



Figure 13. Two spreader trucks working together



Figure 14. Dust generated by landing C-130 at airstrip

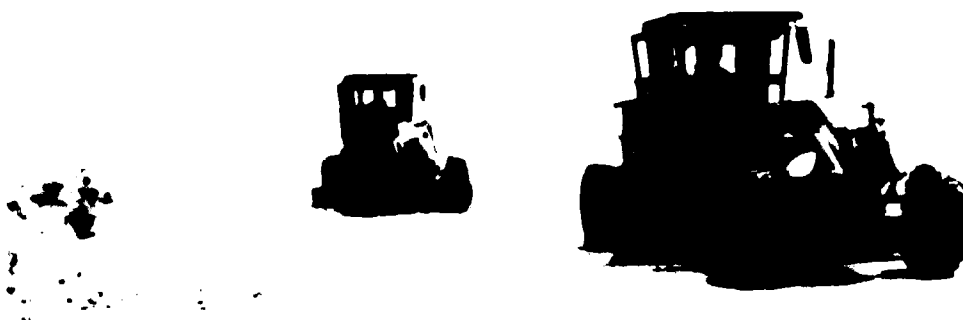


Figure 15. Motor graders blading airstrip



Figure 16. Pneumatic-tired roller compacting airstrip

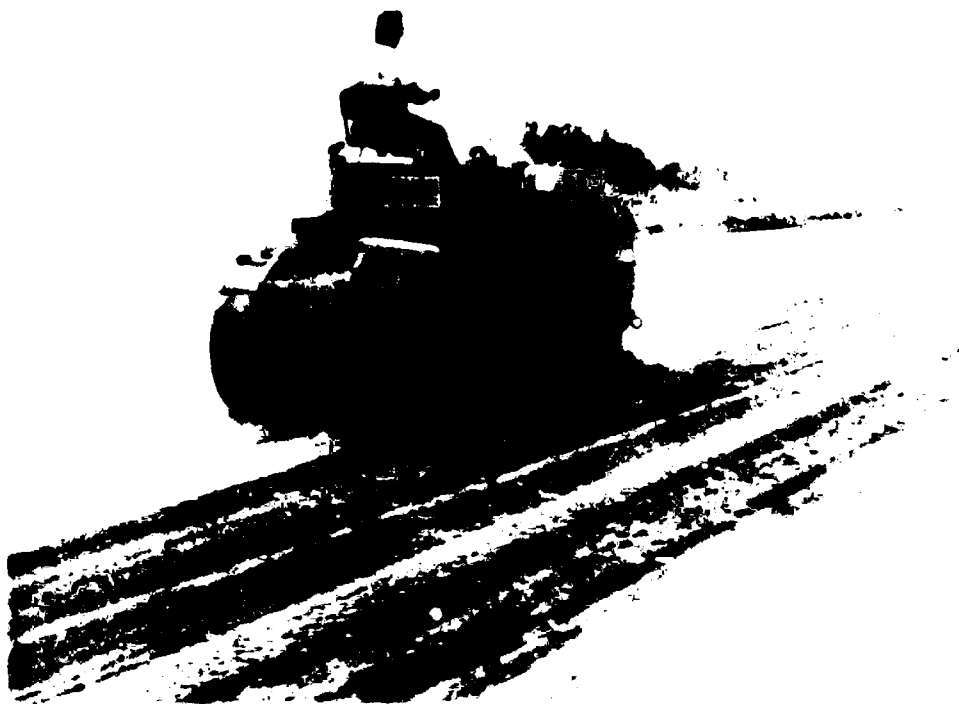


Figure 17. Steel-wheeled roller compacting airstrip

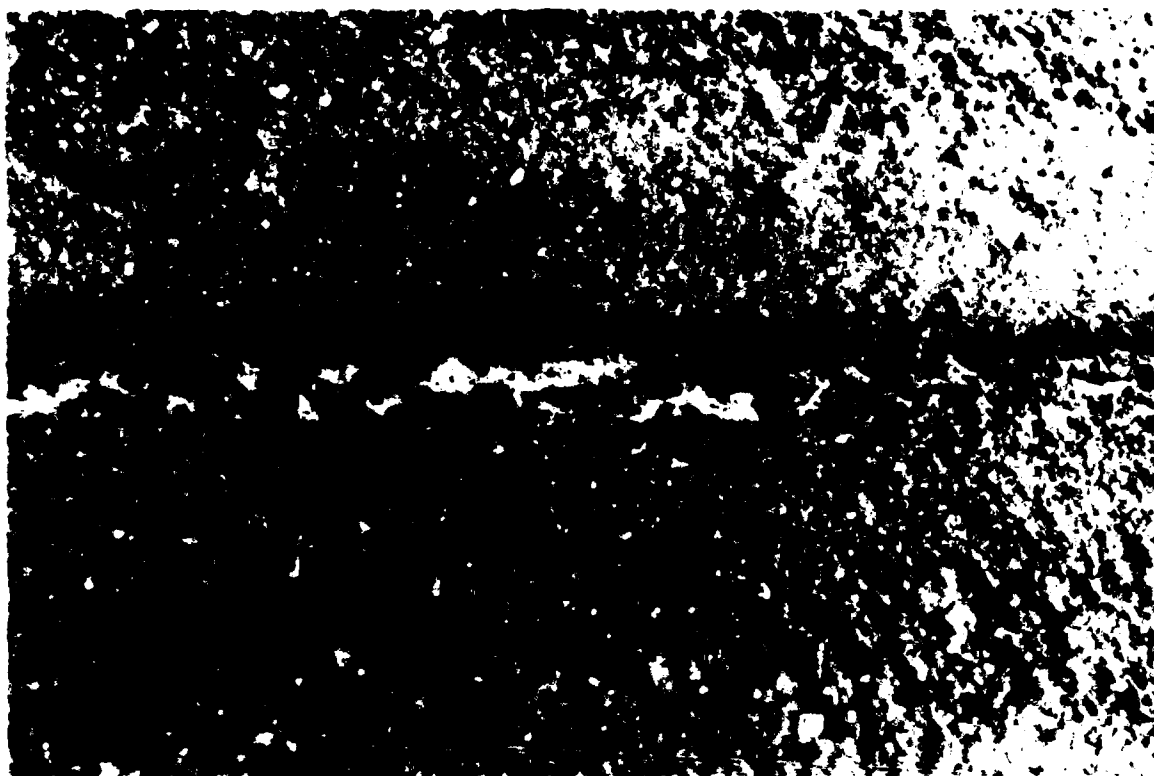


Figure 18. Poor penetration in loosely consolidated areas



Figure 19. Effects of traffic on uncured area



Figure 20. Application of CaCl_2 on airstrip

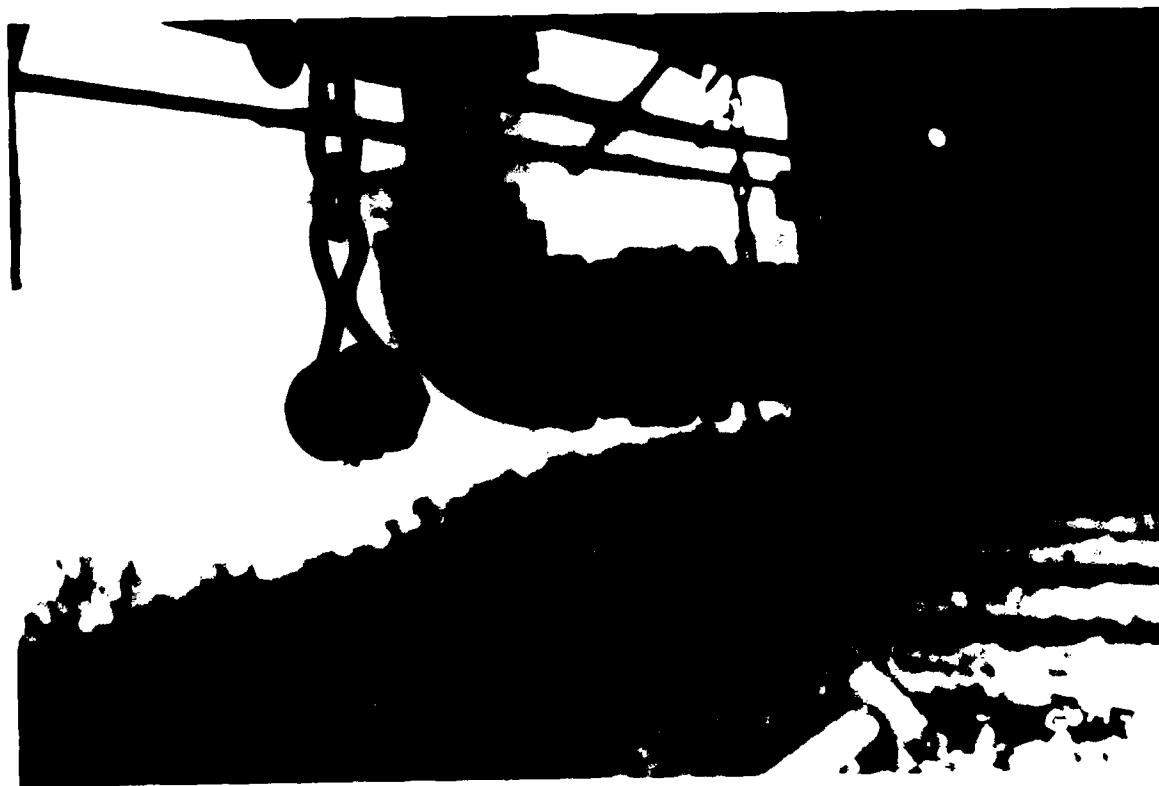


Figure 21. Unloading railroad tank car through 2-in. opening



Figure 22. Unloading railroad tank car from top



Figure 23. Typical surface runoff of MgCl_2 to road shoulders



Figure 24. Car being driven out of untreated area into treated area



Figure 25. Car being driven into untreated area



Figure 26. Completely treated road



Figure 27. Volume of dust 2-1/2 months after treatment with CaCl_2



Figure 28. Airstrip trafficked one week after application
of MgCl_2 (Fort Chaffee, Ark., FTAT FY 85)

APPENDIX A: DUSTPROOFING PROCEDURE SYNOPSIS AND DEMONSTRATION PLAN

Synopsis of Dustproofing Procedure with Brine Solutions

1. The following guidance is the recommended procedure for dustproofing with a brine solution:

a. Planning:

- (1) Determine the area to be treated (square yards).
- (2) Evaluate the surface soils and classify according to Unified Soil Classification System. Consult TM 5-830-3/AFM 88-17, Chap. 3 (Headquarters, Departments of the Army and the Air Force 1974)* for suitability of treatment method and application rate.
- (3) Order enough material to treat area. Initial treatment with 32 percent solution magnesium chloride ($MgCl_2$) should be between 0.42 and 0.50 gal/sq yd. Follow-up maintenance may be scheduled after 8 to 12 months of service life using an application rate of 0.25 gal/sq yd $MgCl_2$. Initial treatment of calcium chloride ($CaCl_2$) should be between 0.27 and 0.36 gal/sq yd with follow-up maintenance of 0.18 gal/sq yd after 8 to 12 months.
- (4) Plan the project so that equipment and personnel are available to accomplish the preparation and application procedures in an orderly step-by-step process.
- (5) Ensure storage facilities and/or a storage area for the dust-control material near the project site.

b. Equipment and Personnel:

(1) Equipment

- (a) Standard motor grader to blade the surface of the selected area to be treated.
- (b) Water truck with displacement pump to prewet the selected area (as necessary).
- (c) A pneumatic rubber-tired roller to compact the selected area before the prewetting operation and after application of the brine solution (as necessary).
- (d) Mobile liquid container device capable of metered application of brine solution.
- (e) If material is shipped by railroad tank cars, a rail-head location must be maintained near the work site. In addition, plumbing attachments consisting of a

* References cited in this appendix are included in the References at the end of the main text.

90- or 45-deg pipe collar which must fit a threaded pipe 4.25 in. in diameter on the bottom of the tank car with the opposite end fitting a flexible loading hose for the brine solution distributor may be necessary (see Figure A1). An alternative to this is the use of pipe fittings consisting of a 2-in. threaded nipple connected to the bottom of the tank car, a 2-in./3-in. bushing, and a 3-in. elbow which are all connected together so that a flexible loading hose can be attached (see Figure 21). Another alternative is to pump brine solution out of the top of the tank car using flexible hose and a powerful pump (see Figure 22).

- (f) A steel-wheeled roller to provide a smooth tight surface (as necessary).

(2) Personnel

- (a) Someone who is familiar with dustproofing operations and equipment involved -1.
- (b) Motor grader operator (as necessary) -1.
- (c) Roller operators (as necessary) -2.
- (d) Prewetting and brine solution distributor operators (as necessary) -2.
- (e) Additional laborer (as necessary) -1.
- (f) Total personnel - from 3 to 7.

c. Site Preparation:

- (1) Blade away all ruts, potholes, washboard, and loose excess surface material to expose a hard surface.
- (2) Compact the bladed surface (as necessary) with a pneumatic rubber tired roller to ensure a hard surface is achieved so that rutting is not caused by traffic.
- (3) Prewet the selected area (as necessary) to reduce surface tension and increase the brine solution penetration. Recommended application rate for the prewetting operation is between 0.03 to 0.30 gal/ sq yd (application rate is dependent upon temperature and evaporation rate).

d. Material Application:

- (1) Spray brine solution with a device capable of metered application (0.27 to 0.36 gal/sq yd for CaCl_2 and 0.42 to 0.50 gal/sq yd for MgCl_2). A 6- to 12-in. overlap of treated strips is required to ensure a uniform application is maintained on the treated area.
- (2) Allow treated area to cure until vehicle passage can be achieved without treated material sticking to wheels. Vehicles can be allowed to traffic gravel roads almost immediately. Finer grained materials may require a longer curing time.

- (3) Compact treated area (as necessary) after curing is complete. Finer grained areas generally require some compaction whereas coarse gravel does not.

e. Maintenance:

- (1) Following periods of low rainfall or low humidity (humidity less than 30 percent), the hygroscopic properties of the brine solution is rendered ineffective or dormant, and dust will appear again. The brine solution can be reactivated with an application of plain water at approximately 0.10 to 0.20 gal/sq yd. Periodic watering should continue for the duration of dry periods.
- (2) Blading will be substantially reduced. If minor rutting occurs, spraying the area with a light application of water will assist the brine solution in binding the small and large soil particles back together again. Only blade the treated area if substantial rutting occurs.
- (3) Brine solution will eventually leach from the treated area with continued exposure to weather extremes. A second application of brine solution should be planned/anticipated following 8 to 12 months of service. The second application procedure is the same as the first, except brine solution is applied at half the previous rate.

f. Safety:

- (1) Local and federal safety regulations apply.
- (2) Military vehicles and aircraft that traffic treated areas should be washed after being exposed to brine solutions. Brine solutions are mildly corrosive materials.
- (3) Normal hygiene practices should be all that is required if the brine solution comes in contact with skin or clothes of personnel.
- (4) Read the manufacturers' application recommendations, safety labels, and material safety data sheet (OSHA form 20).

Demonstration Plan at Fort Campbell, Ky.

Overall Objective

1. The objective of this project is to demonstrate the proper construction techniques, methodology, application rate, and equipment necessary for effective dust suppression. Treatment will be made on gravel roads, a parking area, and a secure forward area assault airstrip. A comparison of the effectiveness of two dust palliatives ($MgCl_2$ and $CaCl_2$) will be made on the gravel roads.

Demonstration Objectives

2. The demonstration objectives are listed below.
 - a. The establishment of appropriate demonstration parameters to meet user (Army and Air Force) requirements.
 - b. The collection of coherent, relevant data.
 - c. The correlated review and analysis of the data.
 - d. The preparation of technology transfer documentation. This will include a technical report, videotape, and fact sheet to be produced by the Waterways Experiment Station (WES) on the accomplished project.
 - e. The dissemination of the project results to the Major Army Commands (MACOM) Engineers for distribution to the Army user.

Project Approach

3. The dustproofing demonstration at Fort Campbell was selected as an FTAT 86 project at the end of FY 85. Coordination was initiated with Mr. Bill Adams, Chief of Buildings and Grounds, Directorate of Engineering and Housing (DEH), Fort Campbell, Ky. Arrangements for accessibility to areas to be treated were made through Mr. Paul Eaves, Range Officer, Fort Campbell, Ky. Mr. Eaves informed the WES Project Engineer that there would be no problems with the exception that access to the forward area assault airstrip could only be granted from 24 May to 7 June 1986. A tentative schedule of events and assignment of responsibilities were mailed to Mr. Adams on 27 January 1986 (see para 8). A contract was awarded to W. W. Sales and Leasing Co. of

Edwardsville, Ill., to deliver and apply approximately 70,000 gal of CaCl_2 and 35,000 gal of MgCl_2 . The MgCl_2 will be shipped in railroad tank cars and will be stored at the Fort Campbell railhead. The CaCl_2 will be trucked from the St. Louis, Mo., area in 5,000-gal tank trailers and will be applied directly from the tank trailers. Arrangements will be made with the Fort Campbell Provost Marshall and Facilities Engineer to permit contractor equipment and personnel onto the military facility. Preparation, application, and documentation will be monitored by the WES Project Engineer. Photography support will be accomplished by the Photography Branch, Information Products Division of the WES. Compilation, correlation, and publishing of the demonstration data will be accomplished by the WES.

Potential Applications

5. The utilization of this type of dust-control procedure and technique being demonstrated at Fort Campbell has the potential to save the Government 10 to 30 percent of costs for maintenance and repair of gravel roads, unsurfaced tank trails, unsurfaced maintenance areas, assault airstrips, and tank and mechanized firing courses. The technology transfer documents (technical reports, videotapes, and fact sheets) will be training aids for personnel in DEH organizations responsible for military facilities while at the same time transferring the knowledge and expertise developed during research and development. Fort Campbell will receive a threefold benefit from this demonstration project, that of (1) gaining additional maintenance and repair of its grounds and roads, (2) receiving a quality product, and (3) receiving first-hand training of their personnel in dust-control procedures and techniques.

Problem Issues

6. The dustproofing unsurfaced areas demonstration project is funded each fiscal year with 1-year money. The execution of the project, planning, and site coordination must be condensed into a short time frame to meet milestones established by DAEN-RDM. This may limit the sponsoring laboratory and the installation in conducting the demonstration during unfavorable periods of the year (outside the construction season). If a contract is let by the

sponsoring installation, the 1-year funds could expire due to contracting period length, poor weather, and/or no contract bidders.

7. For further information contact:

USAEWES
ATTN: Jeff Armstrong/GP-EM
PO Box 631
Vicksburg, MS 39180-0631

Tentative Schedule of Events

8. The tentative schedule of events is listed below.

<u>Event</u>	<u>Period</u>
<u>a.</u> Blading of gravel roads, parking area, and assault airstrip as necessary.	19-23 May 1986
<u>b.</u> WES Project Crew departure for Fort Campbell, Ky.	26 May 1986
<u>c.</u> Site preparation, rolling, and equipment check. Preconstruction photography performed.	27-28 May 1986
<u>d.</u> Prewetting operations and dust palliative application are performed.	27-31 May 1986
<u>e.</u> Rolling of assault airstrip performed.	30 May-7 June 1986
<u>f.</u> Construction completed.	7 June 1986

Schedule of Events for FTAT 86 Dustproofing Demonstration
at Fort Campbell, Ky

Area A AIRSTRIP AT WOODLAWN AND CENTERLINE ROADS

- Blade assault airstrip to remove loose debris and set crown.
(Fort Campbell DEH)
- Compact unsurfaced assault airstrip with rubber-wheeled roller to provide California Bearing Ratio required for landing and avoidance of rutting.
(Fort Campbell DEH)
- Inspect airstrip for low spots, loose debris, crown, compaction, and strength.
(Fort Campbell DEH and WES Technical Monitor)
- Prepare test strips to determine extent of prewetting required.
(Contractor and WES Technical Monitor)
- Prewetting operations (as required) and CaCl_2 application.
(Contractor and WES Technical Monitor)
- Rolling of assault airstrip with rubber-wheeled roller (as required) and using steel-wheeled roller to provide a smooth finish.
(Fort Campbell DEH and WES Technical Monitor)

Area B WEST PERIMETER ROAD

- Blade road/parking lot to remove loose debris and set crown as necessary.
(Fort Campbell DEH)
- Inspect for low spots, loose debris, crown, compaction, and strength.
(Fort Campbell DEH and WES Technical Monitor)
- CaCl_2 application.
(Contractor and WES Technical Monitor)
- Compact with normal traffic.
(Fort Campbell DEH and WES Technical Monitor)

Area-C PATTON ROAD

- Blade road to remove loose debris and set crown as necessary.
(Fort Campbell DEH)

- Inspect for low spots, loose debris, crown, compaction, and strength.
(Fort Campbell DEH and WES Technical Monitor)
- Prewet the surface to be treated to reduce surface tension and increase Magnesium Chloride penetration.
(Contractor and WES Technical Monitor)
- $MgCl_2$ application.
(Contractor and WES Technical Monitor)
- Compact with normal traffic.
(Fort Campbell DEH and WES Technical Monitor)

Area D INDIAN MOUND ROAD AND RECREATION AREA PARKING LOT

- Same as Area B.

Special Instructions

1. Area A is given priority. It has a narrow time slot (24 May-7 June, 1986) in which work must be completed. Areas B, C, and D can be completed as equipment becomes available.

2. All hardblading and compaction should be performed 1 to 3 days prior to application of dustproofing materials to achieve desired condition.

3. After completion of dustproofing construction, Fort Campbell DEH shall periodically inspect treated areas for effectiveness of treatment. Special attention should be given to the assault airstrip, especially after sorties are performed.



Figure A1. Unloading railroad tank car through 4.25-in. opening

APPENDIX B: CHEMICAL ANALYSES

28 March 1986

MEMORANDUM FOR: Mr. Jeff Armstrong
Materials Development Unit, GL

SUBJECT: Analysis for major components of Dustproofing Materials.

1. Seven samples of dustproofing material were received at the Structures Lab, M&CAG on 3 March 1986.
2. The samples were tested for their major constituents, which consisted of calcium, magnesium, sulfate, and chloride. The calcium, magnesium and sulfate were run on the ICP against synthetic standards. The chloride was done by titration against a standardized silver nitrate solution.
3. The sample identifications are listed in Table I, and the results of the chemical analysis are listed in Table II. The results of the analysis are within the limits of the manufacturer's analytical range.


C. L. White
Chemist
Concrete Technology Division

Table I
Sample Identification

<u>Sample No.</u>	<u>Name and Company</u>
1*	bottle labeled Dus-Top Kaiser Chemical
2	Dustgard GSL Minerals & Chemicals
3	Dust-OFF Leslie Salt
4**	technical grade untreated Calcium Chloride Brine Leslie Salt
5*	Liquidow Dow Chemical
6	Calcium Chloride, Liquid Allied Chemical
7	Regular Flake Allied Chemical

* Product used on this project.

** Sample was received with crystals in bottom of container, appears to be super-saturated.

Table II
Dustproofing Material Analysis

<u>Sample No.</u>	<u>Chemical Constituents at 72° F</u>			
	<u>Calcium, %</u>	<u>Chloride, %</u>	<u>Magnesium, %</u>	<u>Sulfate, %</u>
1*	0.03	22.0	8.71	2.24
2	0.03	23.9	9.60	1.78
3	0.04	21.3	8.64	2.13
4**	15.2	28.8	0.50	0.36
5*	14.1	24.6	0.02	0.24
6	15.2	25.5	0.09	0.25
7	31.2	48.1	0.01	0.51

* Product used on this project.

** Sample was received with crystals in bottom of container, appears to be super-saturated.

APPENDIX C: COST BREAKDOWN COMPARISON AND FACT SHEET

This appendix presents a cost comparison between the Dow Chemical, Midland, Mich., source for calcium chloride (CaCl_2) and the Kaiser Chemical, Wendover, Utah, source for magnesium chloride (MgCl_2). The marketing literature product cost for the CaCl_2 is listed at \$36.10/liquid ton (based on a 22-ton unit) and the MgCl_2 is listed at \$33.00/liquid ton (based on orders over 150 tons). Freight is assumed equal for this hypothetical example, and spreading costs are assumed to be \$0.03/gal (costs may vary with prewetting requirements). A range of costs per square yard delivered and applied is given based on application rates of 0.27 to 0.36 gal/sq yd for CaCl_2 and 0.42 to 0.50 gal/sq yd for MgCl_2 (there are 172 gal of CaCl_2 and 181 gal MgCl_2 in a liquid ton of the respective materials).

Cost Comparison

	<u>38% Calcium</u>	<u>32% Magnesium</u>
Product cost/liquid ton	36.10	33.00
Freight	50.00	50.00
Spreading cost/gallon (.03/gal)	+ 5.16	+ 5.43
(prewetting, overhead, profit, insurance)	Add 91.26	88.43
Delivered and spread cost/ton		
	Divided by ÷ 172	÷ 181
	(gallons/ton)	
Equals cost/gallon*	0.5306	0.4886
Application rate	× .27-0.36	× 0.42-0.50
	0.27 → 0.1433	0.42 → 0.2052
Cost/square yard delivered and applied (dollars/square yard)	<u>0.36 → 0.1910</u>	<u>0.50 → 0.2443</u>

Due to numerous product sources and varied transportation methods, the only true cost analysis is a delivered and applied cost to a specific point on a per square yard basis.

* Recent estimates for Tulsa County, Oklahoma, by separate contractors were \$0.5221/gal for CaCl_2 and \$0.4850/gal for MgCl_2 .

FACT SHEET

Liquidow

Supplier: Dow Chemical
4150 S. Sherwood Forrest Blvd, Suite 101
Baton Rouge, LA 70816
(504) 293-2222

Contact: Mr. Paul Santee

Source: Midland, MI

Description: Liquidow is a liquid brine composed mainly of CaCl_2 with other inorganic elements.

Dilution: None. Applied as received.

Application Rate: 0.27 to 0.36 gal/sq yd of 38 percent solution.

Cost: FTAT Project. Bulk cost (1986) \$794.20/22 ton f.o.b. (converts to 20.8 cents/gal).

General: This material is a clear liquid brine product produced in Michigan. It is an effective dust control material with excellent penetration characteristics when used on cohesionless soils.

Dus-Top

Supplier: Kaiser Chemical
7311 E. 41st St.
Tulsa, OK 74145
(918) 627-0100

Contact: Mr. Ken Tucker

Source: Wendover, UT

Description: Dus-Top is a liquid brine composed mainly of MgCl_2 with other inorganic elements.

Dilution: None. Applied as received.

Application Rate: 0.42 to 0.5 gal/sq yd

Cost: FTAT Project. Bulk cost (1986) \$33.00 ton (orders over 150 tons) FOB (converts to 18.2 cents/gal).

General: This material is a liquid brine by-product of the GSL mining operation. It is an amber liquid easily sprayed and an effective dust-control material when used on cohesionless soils.

END

11-87

DTIC