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MISCELLANEOUS PAPER NO. 4-756

GUIDE MANUAL FOR SELECTION AND USE OF DUST PALLIATIVES AND SOIL WATERPROOFERS IN THE THEATER OF OPERATIONS

by

G. R. Kozan

R. A. Pimentel

November 1965

Sponsored by

U. S. Army *Materiel* Command

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Task 05

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CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS.

FOREWORD

This manual was prepared as part of the soil dustproofing and waterproofing research program under Research and Development Project No. 1-V-C-21701-A-046, "Trafficability and Mobility Research," Task 05, "Mobility Engineering Support," under the sponsorship of the Research Development Directorate, U. S. Army Materiel Command.

The manual was prepared by Messrs. G. R. Kozan and R. A. Pimental of the Stabilization Section, Expedient Surfaces Branch, Soils Division, under the general supervision of Messrs. W. J. Turnbull, A. A. Maxwell, and W. L. McInnis of the Soils Division and Mr. W. G. Shockley of the Mobility and Environmental Division, U. S. Army Engineer Waterways Experiment Station (WES).

Director of the WES during the preparation and publication of this manual was Col. John R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

CONTENTS

SUMMARY

This manual provides interim guidance to military engineering personnel in selecting and using materials for alleviating dust and for waterproofing soils in support of operations on expedient airfields and roads in the theater of operations.

The problems of dust and water pertinent to military operations on unsurfaced airfields and roads are defined, and the objectives and limitations of soil surface treatments to alleviate these problems are stated. General procedures for applying a dust palliative or soil waterproofer are outlined, and the implications of these procedures to the ultimate selection of a material are presented. Various types of materials for treating soil surfaces to control dust and/or waterproof soil are described. Criteria to aid in the selection and use of a material, and various factors which may influence the final choice of a material are presented.

GUIDE MANUAL FOR SELECTION AND USE OF DUST PALLIATIVES AND SOIL WATERPROOFERS IN THE THEATER OF OPERATIONS

PART I: INTRODUCTION

Purpose

1. The purpose of this manual is to provide interim guidance to military engineering personnel in selecting and using soil treatment materials for alleviating dust and/or waterproofing soils in support of operations on expedient airfields and roads in the theater of operations.

Scope

2. This manual includes:

   a. Descriptions of available materials for treating soil surfaces to eliminate dust, waterproof soil, or both.

   b. Criteria to aid in the selection of a material for use on various types of airfield complexes designed for operations of U. S. Air Force cargo and jet fighter aircraft, and U. S. Army light cargo, troop carrier, and surveillance aircraft.

   c. Suggestions for rates and methods of application of materials for various soil types and environmental conditions.

   d. Discussion of factors, such as curing time, durability, availability, logistics, storage, and economics, which may be significant in the ultimate choice of material.

3. The information contained in this manual was developed from reviews of existing military and other technical literature,* results of research in progress, and the application of engineering judgment and experience. It is acknowledged that a great deal of information needs to be developed to achieve completely comprehensive and more refined criteria for selecting and using dust palliatives and soil waterproofers on expedient airfields. Until such knowledge is available, however, the military engineer should be informed of various, and perhaps equally acceptable, potential solutions to dustproofing or soil waterproofing problems and of some

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* Pertinent military references are listed in Literature Cited at end of this manual.

of the factors to be considered in the ultimate selection and use of a material.

Background

4. The use of various types of soil treatment materials to control dust on airfields or roadways is described in several military engineering manuals. However, the documentation is very general and does not provide sufficient information to assure the engineer that the most suitable material has been selected or that an optimum application of the material has been specified. Also, very little consideration has been given to the aspect of utilizing soil treatment materials to accomplish the function of waterproofing a soil surface or protecting it against the ingress of surface water. Further, a few proprietary products are presently available which, because of their special characteristics, have distinct advantages for military use over many of the better-known conventional materials.

5. The importance and need for more effective soil surface dustproofing and waterproofing control measures have been demonstrated repeatedly during several recent field maneuvers and exercises involving air and ground mobility operational concepts. As a result, both the Army and the Air Force have indicated a direct interest in the development of more effective and efficient soil treatment systems. However, until such improved materials are evolved, it is considered that a summary of the state of the art of existing materials can provide interim solutions to many current problems. It is anticipated that this manual will be revised or supplemented periodically to keep it abreast of technological developments and provide up-to-date information on soil treatment materials and their use.

PART II: THE PROBLEM

Facilities Requiring Treatment

6. The successful execution by the Armed Forces of the air mobility concept depends on the availability of, or the ability to rapidly construct, a network of airfields in the theater of operations to accommodate various cargo and tactical support aircraft. Since the time and effort to prepare the airfield network must be kept to a minimum, full advantage must be taken of the existing terrain and soil conditions, and of the operating characteristics of the using aircraft in the planning and construction of the required airfield facilities. As presently conceived, airfields are to be provided in rear, support, forward, and battle areas with a service life of a few days to possibly a year, depending on the operational mission, with a minimum of maintenance. In general, these airfields will be unsurfaced or, at best, will be provided with expedient surfacing such as prefabricated landing mat or membrane.

7. In addition to the primary elements of an airfield, a system of service or peripheral roads is generally required as part of the overall airfield complex. Besides providing a means for vehicular movement in the airfield area, roads may be needed to connect with other airfields, ports, railheads, or major arterial road facilities. Although no specific criteria exist for developing a supporting road system, the roads normally will be expected to carry a moderate volume of traffic of relatively light vehicles and possibly a small volume of heavy truck traffic. Depending on their planned function, the roads may range from simple cross-country trails to improved two-lane facilities. A generally common feature of the airfield support road system is that the roads are unsurfaced.

The Dust Problem

Definition and effects

8. A major problem in connection with operations of aircraft on unsurfaced or limited-surfaced airfields and operations of vehicles on unsurfaced roads is dust. The term "dust" can be defined simply as particles of

soil which have become airborne. As a general rule, dust consists predominantly of soil particles finer than 0.074 mm (i.e. passing the No. 200 sieve). Dust can have significant adverse effects on the overall efficiency of aircraft and vehicle operations by increasing downtime and maintenance requirements, shortening engine life, reducing visibility, and deleteriously affecting health and morale of personnel. Dust clouds also can aid the enemy by revealing the position and scope of operations.

Factors influencing dust cloud formation

9. The presence of or relative amount of dust-size particles in a soil does not necessarily indicate a dust problem or the severity of dust which will result in various situations. Some of the factors which contribute to the generation, severity, and perpetuity of dust clouds include overall soil gradation, moisture content, density, smoothness of the ground surface, presence of salts or organic matter, vegetation, wind velocity and direction, and air humidity. Depending on soil conditions and environment an external force imposed on a ground surface will generate dust clouds of varying density, size, and height above ground. Dust clouds may be generated by aircraft propeller wash, engine exhaust blast, jet-blast impingement, and draft of moving aircraft. Further, the kneading and abrading action of aircraft tires can loosen particles from the ground surface which may become airborne. Moving ground vehicles generate dust clouds through disturbance of the air and the abrading action of the tires.

Sources of dust

10. On unsurfaced airfields, the runways, taxiways, shoulders, overruns, and parking areas are primary sources of dust. On unsurfaced roads, only the width of road over which vehicles actually travel is of primary concern; adjacent shoulders do not contribute significantly to the dust problem. In areas of open terrain and prevailing winds, soil particles can be blown onto an airfield or road and contribute to the dust problem despite adequate initial control measures used on the soil within the constructed area. Where it is evident that such a condition may be severe, it may be necessary to make additional applications of a dust palliative to an airfield or road to maintain control.

The Water Problem

11. The ability of an airfield or road to sustain operations depends on the bearing strength of the ground. Although an unsurfaced facility may possess the necessary strength when initially constructed, it may lose strength when wet to the extent traffic operations will be adversely affected. Fine-grained soils or granular materials which contain an excessive amount of fines generally are more sensitive to water changes than coarse-grained soils. Surface water also can contribute to the dust problem by eroding or loosening material from the ground surface which dries and during dry weather becomes dust.

12. Water may enter a soil by the permeation of precipitation or ponded surface water, by capillary action of underlying groundwater, by a rise in the level of the water table, or by condensation of water vapor and accumulation of moisture under a vapor-impermeable surface. As a general rule, areas which have a shallow groundwater table have a low soil bearing strength, and these areas should be avoided wherever possible. A prolonged wet season may result in a rising water table and a soil strength problem in areas which normally have high bearing strength. When this condition occurs, a thin surface treatment will not be suitable protection, and other measures will have to be taken. These measures might include (a) placement of a compacted fill of a good draining soil or possibly a stabilized soil to a suitable height above the groundwater table, (b) use of prefabricated membrane or an asphalt seal as a moisture barrier at a suitable depth below the ground surface, (c) application of soil stabilizers to construct a water-tolerant layer of sufficient thickness to support the applied loads, or (d) use of prefabricated metal surfacing to improve the load-carrying capability of the weakened in-place soil. Discussion of the various means of protecting against water ingress from sources other than the ground surface is outside the scope of this report. In many instances, the problem of surface water can be lessened considerably by good grading, compaction, and drainage practices. The latter includes providing adequate cross-sectional drainage grade and adequate grades for side ditch drainage.

Functions and Limitations of Soil Surface Treatments

Dust palliatives

13. The primary function of a dust palliative is to prevent soil particles from becoming airborne. Dust palliatives may be used for controlling dust on nontraffic or traffic areas, or both. If nonperforated prefabricated landing mat, membrane, or conventional pavement surfacing is used on airfield traffic areas, dust palliatives would be used only on nontraffic areas. The palliatives for nontraffic areas must be capable of resisting the maximum intensity of air blast from the using aircraft. Dust palliatives for use on traffic areas must be capable of withstanding the abrasion of the aircraft tires as well as air blast. A palliative might provide the necessary resistance to air blast and still be totally unsuitable as a wearing surface. One important factor in determining the suitability of a dust palliative in traffic areas is the extent to which the surface will rut under traffic. If the soil bearing capacity is such that the surface will rut under traffic, a shallow depth palliative treatment can be broken up and subsequently stripped from the ground surface. Some palliatives will withstand deformations better than others, but ruts of 1-1/2 to 2 in. deep will usually result in the virtual destruction of any thin layer or shallow-penetration dust-palliation treatment.

14. The preceding statements also apply to the use of dust palliatives on supporting road facilities, which are considered as traffic areas. Most of the dust raised on an unsurfaced road results from the abrasive action of vehicle tires and the draft created by moving vehicles. Rutting can cause a breakup of a shallow palliative-treated layer, thus exposing untreated soil which may become a source of dust. As a general rule, the use of dust palliatives for traffic areas of either airfields or roads should be considered only when the soil surfaces are sufficiently firm to support the design traffic loads with little or no rutting. If used where ruts are likely to occur, the palliatives will be short-lived and frequent retreatment probably will be necessary.

Soil waterproofers

15. The function of soil surface waterproofers is to protect the soil against attack by water and thus preserve its in-place or

as-constructed strength during wet weather operations. Soil waterproofers generally will be used only on traffic areas of airfields and roads. In some cases, waterproofers may be used to prevent excessive softening of areas, such as shoulders or overruns, which are normally considered as non-traffic areas. They may also be used to prevent soil erosion by surface water runoff. As in the case of dust palliatives, a thin or shallow-depth soil-waterproofing treatment will lose its effectiveness when excessive rutting occurs, and thus can be used effectively only in areas which are initially firm.

16. Many soil waterproofers also function well as dust palliatives, and these materials should be considered for use in areas where the climate will create both wet and dry soil surface problems.

PART III: METHODS OF APPLICATION OF SOIL TREATMENT MATERIALS

17. The method of applying a dust palliative or soil waterproofer will depend on the type of material used, the type of soil to be treated, and the purpose of the treatment. Two general techniques can be used to apply dust palliatives and soil waterproofers to soils: the admix method, and the surface penetration method. Prior to selection of a palliative, the implications of these two methods of application in relation to the particular job requirements should be considered carefully.

Admix Method

18. In the admix method, the soil treatment material is blended with the soil to achieve a uniform mixture. This method must be used when the soil treatment material is a solid. However, the admix method may be used with a liquid material when treatment to a depth greater than that which can be achieved by the surface penetration method is desired. Because the admix method requires more effort, time, and equipment than the surface penetration method, it should be used only when time permits or when there is no material available that can be applied by the surface penetration method. If a wide choice of materials is available, then a material for admix application should be selected only where it is essential that the treated layer be 3 in. or greater in thickness. This thickness of treatment is not required on nontraffic areas, but may be required to provide a dust- or waterproof surface in traffic areas where rutting of as much as 2 in. will occur under traffic. Admixing can be accomplished either in place or off site.

In-place admixing

19. In-place admixing is the blending of soil and treatment material on the site. The surface soil is loosened (if necessary) to a depth approximately equal to the desired thickness of the treated layer, the soil treatment material is added in the desired quantity and blended with the surface soil, and the mixture is compacted by rolling. Equipment which can be used for an in-place mixing operation includes rotary tillers,

pulverizer-mixers, graders, scarifiers, disk harrows, or plows. Where conventional stabilization traveling mixers are available, good blending generally will be achieved with two or three coverages over the area. If the surface soil is easily tilled (e.g. sandy or silty soils) pulverization is not required before treatment materials are added. If the soil is hard or firm (e.g. dry clay), it must be loosened and pulverized before the treatment material is applied. Solid materials may be spread by hand or by mechanical spreaders. Liquid materials should be placed with distributor equipment. When equipment such as disk harrows or plows is used, the effectiveness of mixing will generally be very poor. A grader will do a reasonably good mixing job by alternately windrowing and blading a soil treatment mixture until the mix appears uniform. The mixture is then smoothed and compacted.

Off-site mixing

20. Off-site mixing is generally used where in-place construction is not desirable and soil from another source would provide a more satisfactory treated surface. Off-site mixing may be accomplished with stationary mixing plants, or it can be done expediently by windrow-mixing with graders (as described in paragraph 19) in a central working area. The major disadvantage in any off-site operation is having to transport and spread the mixed material.

Surface Penetration Method

21. In the surface penetration method, the soil treatment material is placed directly on the surface soil by spraying or other similar means. This is the most rapid and efficient method of applying liquid materials. Depending on the material, surface penetration applications may be accomplished with a liquid pressure distributor, by a gravity-flow water distributor, or by hand hosing or spraying. Hoses or hand-sprayers should be used only for small areas, for maintenance, or where good uniformity of a treatment is not critical.

22. The effectiveness of the surface penetration method depends primarily on the viscosity of the treatment material and the permeability of the soil surface. Predominantly coarse-grained soils are more readily

penetrated than fine-grained soils. Where the soil is extremely clayey, penetration with a liquid material may be impossible. In this case the admix method may be resorted to; or treatment may be accomplished by lightly scarifying the surface soil to a shallow depth (1 to 2 in.) followed by spraying the liquid and then lightly rolling the surface. In some soils, such as silts or silty clays, penetration with some materials can be facilitated by a light initial sprinkling of the surface with water.

23. Because of the limited depths to which any liquid material can penetrate when applied at a reasonable application rate (not in excess of 1.5 gal per sq yd), only a thin treated surface layer can be achieved. For nontraffic areas of airfields subjected to the maximum intensity of propeller blast, shallow penetration treatments may be adequate. However, nontraffic areas of airfields subjected to a maximum back blast of jet aircraft will likely erode very readily and no penetration treatment will survive for long. A shallow-depth penetration treatment subjected to direct tire traffic (either aircraft or ground vehicles) can be worn away by traffic or, if a small area of untreated soil is exposed, may be stripped from the surface by subsequent traffic. Also, if rutting occurs, the effectiveness of a surface penetration treatment will be destroyed rapidly.

PART IV: TYPES, DESCRIPTION, AND UTILIZATION OF SOIL TREATMENT MATERIALS

Types

24. A wide selection of materials for dust control and/or soil waterproofing is available to the engineer; however, no one material can be singled out as being the most universally acceptable for all problem situations. The various types of materials have been grouped into five general classifications as follows: (a) Group I, bituminous materials; (b) Group II, cementing materials; (c) Group III, resin systems; (d) Group IV, salts; and (e) Group V, miscellaneous materials.

25. A summary of various materials potentially suitable for theater-of-operations use and a guide to their application as either a dust palliative or a soil waterproofer are given in table 1. The sources from which most of the materials are available and the approximate costs for estimating purposes are given in table 2. It should be recognized that the information which is presented in table 1 is based on limited testing of these materials to date for the particular application to the military theater-of-operations airfields or roads. However, the data presented represent the best estimate that can be made of the applicability of the materials based on existing information.

26. An explanation of the information provided in table 1 is given below.

a. Column 1 identifies the material by type.

b. Column 2 lists the form in which the material is usually supplied.

c. Column 3 shows the acceptable method of application. Where a material may be applied either as an admixture or as a surface penetration treatment, the preferred and most generally used method is indicated first.

d. Column 4 states the applicable soil range, i.e. the range of soils which will normally result in reasonably satisfactory results with the particular material. In some instances, the materials may be used outside of this range but with the recognition that the effectiveness which could be achieved will be decreased. In general, granular-type soils (gravel to coarse sand) may or may not require treatment for dust control or waterproofing, depending on the amount of fines present. Fine sands (e.g. dune or windblown sands) will probably require a dust palliative but not a waterproofer. Soils ranging from silty sands to highly plastic clays may require a dust palliative and/or a soil waterproofer.

e. Columns 5, 6, and 7 show the primary function of the materials as either a dust palliative or a soil waterproofer and, where known, the relative degree of effectiveness that can be expected for the indicated function. The applicability to both the traffic area (column 5) and nontraffic area (column 6) is given under the dust palliative function. The waterproofing function is given for the traffic area only (column 6), since there will not be a general need for maintaining strength in nontraffic areas. If such a requirement arises, the materials indicated as suitable for traffic areas can be considered acceptable for use in nontraffic areas.

f. Columns 8 and 9 indicate quantity requirements applicable to the soil range indicated in column 4. The lower quantity of the range shown is generally suitable for the coarser soils, and the higher quantity is needed for the finer soils. These quantity requirements are given only as a general guide; in some cases, effective results may be achieved with lesser or greater amounts than those given in the table.

g. Column 10 indicates minimum curing time for the various materials. The curing requirements are specifically pertinent to the function as a dust palliative and/or waterproofer in traffic areas. In nontraffic areas, curing is not usually critical, and adequate dust palliation can be expected immediately after an admixture is compacted or, in the case of penetration materials, immediately after the liquid has been completely absorbed by the soil surface.

h. Column 11 is self-explanatory.

27. To aid in the effective use of table 1 in selecting an appropriate material for a particular situation, a brief description of each of the materials and an amplification of their use are given in the following paragraphs.

Group I, Bituminous Materials

28. Conventional types of bituminous materials that may be used for dust palliation and soil waterproofing include cutback asphalts, emulsfied asphalts, and road tars. A patented commercial cutback asphalt, called Product A, has been listed separately in this group since it has unique

penetrating and curing characteristics which are not inherent in conventional cutback asphalts. Bituminous materials are perhaps the most versatile of soil treatment materials since they can be applied either by the admix (prepared in place or off site) or the surface penetration method, and are generally effective both as dust palliatives and soil waterproofers. They can be used to treat traffic and nontraffic areas, but have a general disadvantage, when used in traffic areas particularly, of requiring curing times of at least 24 hr under ideal conditions. Also, they are particularly sensitive to adverse climatic environment. Although there are no simple guides or shortcuts for designing mixtures of soil and bituminous materials, maximum effectiveness of soil-bituminous material admixtures can usually be achieved if the soil characteristics are within the following limits.

a. Liquid limit less than 30 percent.

b. Plasticity index less than 6.

c. From 50 to 100 percent finer than No. 4 sieve.

d. More than 10 percent but less than 35 percent finer than No. 200 sieve.

e. Maximum particle size less than one-third the compacted thickness of the treated soil layer.

29. For best results, quantities of residual bituminous material used should generally range from 2 to 3 percent of dry soil weight for granular materials to 6 to 8 percent for heavy clays. The presence of mica in a soil is deterimental to the effectiveness of soil-bituminous material admixture.

Cutback asphalts

30. A cutback asphalt is a blend of an asphalt cement and a petroleum solvent. Cutbacks are classified as rapid curing (RC), medium curing (MC), and slow curing (SC), depending on the type of solvent used and its rate of evaporation. Each cutback is further graded by its viscosity. The RC, MC, or SC types of cutback asphalts of low- to medium-viscosity grades are suitable for dust palliation or soil waterproofing. RC and SC cutback grades of 70 and 250 (approximately equivalent to former grade specifications of 1 and 2) and MC cutback grades of 30, 70, and 250 (approximately equivalent to former grade specifications of 0 to 2) are generally used.

31. When admixed into soil to depths of 3 in. or more on a firm subgrade, cutbacks will produce a fairly durable wearing and waterproof surface. They are less satisfactory when applied by the penetration method, especially in soils containing a high percentage of fines. The best results from either the admix or the surface penetration method are obtained by preheating the asphalt. The MC-30 grade can be sprayed without being heated if the temperature of the asphalt is 80 F or above. When cutbacks are applied as admixtures, blending should be continued until a uniform mix is achieved. In the case of SC or MC type asphalts, it will be necessary to allow the soil-asphalt mixture to aerate for a period of time to remove the volatiles before compacting. Soils should be fairly dry when the cutbacks are to be admixed (moisture content of 2 to 3 percent for granular soils and up to 6 to 8 percent for fine-grained soils, depending on amount of fines). When cutback asphalts are applied by the penetration method, a slightly moist soil surface may assist penetration.

Emulsified asphalts

32. Asphalt emulsions are a blend of asphalt, water, and an emulsifying agent and are available as either anionic emulsions or cationic emulsions, depending on the emulsifying agent. The slow-setting anionic emulsions of grades SS-1 and SS-1h (for cool and warm weather use, respectively) can be used as admixtures or penetration treatments. The medium-setting anionic emulsion of grade MS-2 also can be used as an admixture treatment for granular materials and coarse sands, but greater care must be exercised in its use, as compared to the slow-setting grades, to prevent it from breaking prematurely. The anionic emulsions are normally further diluted with from 1 to 7 parts water by volume prior to use. As a general rule, a 3-to-1 water-to-emulsified asphalt dilution will be satisfactory for most applications. The slow-setting cationic emulsions of grades SS-K and SS-Kh (for cool and warm weather use, respectively) also can be used as admixtures or penetration treatments. Greater care must be exercised in using cationic emulsions as compared to anionic emulsions, particularly when applying them by admixing. Medium-setting cationic emulsions of grades SM-K (for mixing with sand) and CM-K (for mixing with coarse aggregate) also can be used as admixture treatments, but greater care must be exercised as compared to the slow-setting grades. Cationic emulsions are

simplest to use without further dilution with water. If dilution is desired, the water used must be free of any impurities, minerals, or salts which might cause breaking of the emulsion within the distribution equipment.

33. Emulsions have an advantage over cutbacks in that no preheating of the material is necessary for their use as admixtures or penetration treatments. As admixtures to soil emulsified asphalts are applied at soil moisture contents which will allow the emulsion to break prior to compaction, but which will not interfere with the coating of soil particles. For satisfactory emulsion treatment, soil moisture contents generally should not exceed 5 percent in granular soils and should be somewhat less in soils with a high clay or silt content. All emulsified asphalt systems, and particularly the cationics, are extremely sensitive, and when used improperly, the emulsion may either break prematurely or not break at all. Therefore, only personnel having knowledge of the materials and prior experience in their application should use emulsions, particularly as admixtures. Emulsions are less difficult to use for penetration application and should provide good results in most instances.

Road tars

34. Road tars are viscous liquids obtained by distillation of crude tars obtained from coal. Tars derived from other basic materials are also available, but are not normally used as soil treatments. Road tar (RT) is graded by its viscosity and is available in grades ranging from 1 to 12. It is also available in the cutback from (RTCB) of viscosity grades 5 and 6, and in the emulsified form. Road tar emulsions are difficult to prepare and handle, and are not considered suitable for expedient theater-of-operations use. Grades RT-3 to RT-6 and RTCB-5 and RTCB-6 can be used as admixtures in the same manner as cutback asphalts. Grades RT-1 to RT-6 and the cutback grades can be used as surface penetration treatments. The low viscosity grades RT-1 and RT-2, and the RTCB grades can be applied at temperatures as low as 60 F without heating. The road tars, particularly the road tar cutbacks, generally have better penetrating characteristics than asphalts. The road tars will produce excellent surfaces, but curing proceeds very slowly, and several days or even weeks may be required to achieve a completely cured layer. Road tars are probably more suitable

for use on nontraffic areas where curing time is less critical. Road tars are susceptible to temperature changes and may soften in hot weather or become brittle in cold weather.

Product A

35. Product A is a special proprietary asphalt product which is similar to an MC-30 grade cutback and has certain chemical additives to enhance its soil penetrating characteristics. It is suitable for application by penetration to soils which are relatively impervious to conventional cutback and emulsion systems. Silts and moderately plastic clays (to a plasticity index of 15) can be treated effectively with this material. Product A cures rapidly and can be trafficked in 2 to 8 hr after placement. As with other cutbacks, it must be heated to 130 to 150 F to permit uniform spraying with an asphalt distributor.

Group II, Cementing Materials

36. The conventional cementing-type stabilizing materials, portland cement and hydrated lime, are primarily used to improve the strength of weak soils. However, when they are admixed with soils in relatively small quantities (2 to 5 percent by dry soil weight), the modified soil is more resistant to dusting and will maintain a higher strength than the untreated soil. The use of portland cement or lime as a dust palliation or waterproofing treatment is recommended only as a very temporary measure and when other more effective materials are not available. Cement is generally suitable for all soil types, provided reasonably good mixing can be achieved; whereas, lime is applicable only to soils containing a high percentage of clay. For maximum results, the moisture content of the cement-soil or lime-soil mixture should be at or near optimum for compaction.

Group III, Resin Systems

37. Many resinous compounds have been investigated as dust palliatives and soil waterproofers. Many show potential for such purposes, but they also have certain limitations which render them undesirable for use in the theater of operations.

Lignin

38. Lignin is a by-product of the manufacture of wood pulp. It is usually found in liquid form but can be procured in dehydrated or powder form. It is most suitable as a binder additive for granular materials and sands, but can be used in silts and clay soils with limited effectiveness. In the liquid form, it can be sprayed on a soil surface as a temporary measure. Lignin is soluble in water and is readily leached from the soil; thus, repeated applications would be required in areas of periodic rainfall.

Product B

39. Product B is a proprietary material consisting of a petroleum resin base in a water emulsion. Its sole function is dust palliation. It is more suitable for application in nontraffic areas, but will provide some dust control in traffic areas if little rutting occurs. As supplied, Product B can be diluted with any proportion of water. For most applications, a dilution of 4 parts water to 1 part Product B (by volume) applied at a rate of 0.5 to 1.5 gal per sq yd will be satisfactory. In some cases, dilutions of as much as 10 parts water to 1 part Product B can be used satisfactorily. The solution can be applied with a pressure distributor or water truck or sprayed onto the ground surface with a hose. The product cannot be stored for prolonged periods at temperatures below 20 F or above 120 F, because the emulsion will break and the material cannot be reemulsified. Also, it has been determined that soils containing high percentages of iron oxide are not responsive to treatment with Product B. Generally, such soils can be identified by their red or brownish-red color.

Concrete curing compounds

40. For treatment of silts and highly plastic clays where penetration cannot be readily accomplished, resin systems which will provide a thin plastic coating on the soil surface can be used. Such compounds are used to seal the surface of freshly laid concrete during the curing phase. Although resinous concrete curing compounds are probably available from many commercial sources, tests have been performed on only one proprietary compound, Product C, to date. This specific resin is a paraffin base material which dries to a thin, moderately flexible film in 4 hr under good drying conditions. Because of the thinness of the film, treatment with this product is only moderately effective under traffic and should be restricted

to traffic areas where no rutting will occur.

41. A disadvantage of Product C, or equivalent concrete curing compounds, is its high cost ($0.60 to $0.90 per gal). This is partly offset by the low application rate required (0.1 to 0.2 gal per sq yd) and the favorable logistics aspect of the small quantity requirement. Standard asphalt pressure distributors can be used to place the resin, but the conventional spray nozzles should be replaced with smaller-opening spray nozzles to achieve a uniform distribution at a low application rate. Also, special care must be taken to clean out the distributor after use to prevent the resin from setting up in the equipment. This can be done by flushing the equipment with gasoline, naptha, kerosene, diesel fuel, mineral spirits, or other general solvents.

Group IV, Salts

42. Salts, particularly sodium chloride and calcium chloride, have been used with varying degrees of success as soil treatment materials. Calcium chloride is deliquescent and, if the relative humidity is about 30 percent or greater, will absorb moisture from the air. A calcium chloride-treated soil will also retain more moisture than the untreated soil under comparable drying conditions. Its primary function is dust palliation, and its use generally is limited to lightly traveled roads and possibly nontraffic areas of airfields. Sodium chloride achieves some dust control by virtue of retaining moisture and also by some cementing by salt crystallization. Both calcium chloride and sodium chloride are soluble in water and are readily leached from the soil surface; thus, frequent applications are usually required. Salts in the form of a concentrated solution or brine may also be applied by the surface penetration method. Frequent applications of a salt solution can ultimately build up a thin, crusted surface which will be fairly hard and free of dust. Salt applied as a solution is susceptible to leaching by rainfall. Salts are highly corrosive to metal and should never be used where they may result in damage to aircraft.

Group V, Miscellaneous Materials

Water

43. As a very temporary measure for allaying dust, a soil surface can be sprinkled with water. As long as the ground surface remains moist or damp, dust can be controlled to a slight degree with water. Depending on the soil and climate, frequent treatment may be required. Excessive quantities of water should not be applied to clay soil surfaces, since a muddy or slippery surface may result when the soil is wet and a more severe dust condition after it dries.

Various oils

44. Waste oil, bunker oil, crude oil, or other types of oils which may be available can be used as temporary dust palliatives. Oils are mostly applicable for use on lightly traveled roads and nontraffic areas of airfields. Periodic treatment or multiple applications by spraying may be necessary. After several treatments, a packed, oily soil crust is usually developed which has good resistance to abrasion by traffic and which is moderately resistant to water. Good penetration by the oil can be expected in the more permeable soils. Clayey soils or tightly knit surfaces may resist penetration, in which case it may be desirable to lightly scarify the surface, apply 0.25 to 0.5 gal of oil per sq yd, and lightly compact the surface.

Turf

45. Although not included in table 1, turfs or grasses are extremely effective in preventing dust formation. Time will generally not permit the growing of turf at most airfield complexes, but every advantage of existing ground vegetation should be taken in planning an airfield. Unnecessary stripping of natural grasses during construction should be avoided wherever possible.

PART V: APPLICATION CRITERIA

46. Information has been presented in Part IV which will assist the engineer in selecting a material and in establishing a suitable application rate for a particular function. For purposes of planning, estimating total material and effort requirements, and utilizing the selected soil treatment material in the field, the engineer is required to (a) define the dimensional boundaries (i.e. area) of an airfield or road to be treated, (b) determine an appropriate depth for an admix treatment if selected, and (c) establish the adequacy of soil strength where a soil surface treatment in traffic areas is contemplated. Tentative criteria have been developed to resolve item (a), but only general guidance can be offered at present to assist in resolving items (b) and (c).

Airfields

Dimensional boundaries

47. Traffic areas. The traffic areas or main elements of an airfield include the runway, parallel and lateral taxiways, overruns, and parking aprons. It is assumed that the basic design of the airfield, which will vary with the planned operational function and characteristics of the using aircraft, will be known. Application of a soil treatment material in traffic areas will therefore be required over the entire design area of the main elements.

48. Nontraffic areas. Nontraffic areas of airfields are those areas, adjacent to main elements, which do not normally carry traffic. The primary purpose of treating the nontraffic areas is to control dust. The degree to which dust is controlled in the nontraffic areas depends on the distance to which the treatment extends beyond the edges of the traffic areas. This distance or width varies with the type of aircraft involved, and also depends on the particular areas of the airfield to be treated. In table 3, recommended widths for dust control treated areas adjacent to various traffic areas of an airfield are given for different using aircraft. Widths are prescribed for two levels of dust control, maximum effort control and minimum effort control. Treatment to the widths listed

under "maximum effort control" will result in virtually complete dust alleviation under the severest dust-generating condition, which occurs when the aircraft wanders to the edge of the traffic area. Such a condition should occur only infrequently on the runway, and normally not at all on the taxiway. Treatment to the widths listed under "minimum effort control" will result in a significant alleviation of dust during the majority of operations, but will not necessarily provide complete control. Widths of treatment less than those indicated for minimum effort control should not be considered. Any width between the extremes indicated in table 3 can be selected, depending on the extent to which dust control is desired, or as dictated by material and construction effort limitations. For any selected width and with knowledge of the basic design dimensions of the main elements of an airfield, the gross areas to be treated can be readily determined.

Admix treatment depth

49. Treatment depth requirements apply exclusively to the admix method of application. A minimum treatment depth of 3 in. is recommended for any admixture application. This depth of treatment generally will be adequate for all nontraffic areas; however, depths from 3 to 6 in. should be considered for traffic areas, depending on the ability of the surface soil to resist rutting. This resistance is a function of soil strength, which is discussed in the following paragraph.

Soil strength

50. A major factor influencing the suitability of either a surface penetration or an admixture treatment is the bearing capacity of the existing or prepared ground surface, particularly in traffic areas. Specific strength criteria for predicting the performance of soil treatment materials for different levels of usage by various aircraft are not presently available. As a general rule, the effectiveness of a surface penetration treatment will be destroyed rapidly when surface rutting exceeds 1-1/2 in. to 2 in. Similarly, an admixture treatment loses its effectiveness when the depth of rutting approaches the depth of the treated layer. In the absence of specific strength criteria, considerable judgment must be exercised by the field engineer. As a very rough guide, rutting will be within tolerable limits if the soil strength is two to three times greater

than the minimum strength required for operations on unsurfaced soils.

Roads

Dimensional boundaries

51. In applying a dust palliative or a soil waterproofer to a road, treatment will be accomplished over the full width of the roadway proper. Normally, this will be 8 to 10 ft per traffic lane. Treatment of the shoulders will generally not be required, although this will be at the discretion of the engineer. When the length of the road network is known and an approximate width of treatment has been selected, the total area involved can be determined readily.

Treatment depth

52. The provisions of paragraph 49 are also applicable to treatment depth requirements for roads. A minimum depth of 3 in. is required for admixture treatment, and depths up to 6 in. should be considered if rutting is anticipated.

Soil strength

53. The soil strength required for a road is dictated by the type and volume of vehicles which will use the facility. Generally, unsurfaced roads for prolonged use will be initially constructed to sustain vehicle operations without deep rutting. An existing or constructed road with a soil strength of 15 to 20 CBR normally will satisfactorily sustain traffic of heavy vehicles and can be effectively treated.

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Table 1

Summary of Dust Palliatives and/or Soil Waterproofers for Theater-of-Operations

Materials* (1)	Form of Material (2)	Acceptable Application Method(s) (3)	Applicable Soil Range (4)	Primary Function, Area of Use, and Degree of Effectiveness** — Dust Palliative: Traffic (5)	Dust Palliative: Non-traffic (6)	Waterproofer (Traffic Area Only) (7)	Quantity Requirements†: gal per sq yd (8)	lb per sq yd (9)	Minimum Curing Time (10)	Remarks (11)
Group I: Bituminous Materials										
Cutback asphalts										
RC-70 to RC-250	Liquid	Admix	Gravel to sand	M	V	M	0.18-0.25	1.5-2.0	12-24 hr	All cutback asphalts will require preheating for penetration or admix application
		Penetration	Gravel to silty sand	M	V	M	0.25-0.50	2.1-4.0	12-24 hr	
MC-70 to MC-250	Liquid	Admix	Sand to silt	M	V	M	0.25-0.55	2.0-4.5	> 24 hr	
MC-30 to MC-250	Liquid	Penetration	Gravel to silty sand	M	V	S	0.25-0.50	2.1-4.0	> 24 hr	
SC-70 to SC-250	Liquid	Admix	Sand to clay of moderate plasticity	M	V	M	0.55-0.72	4.5-6.0	> 24 hr	
		Penetration	Gravel to silty sand	M	V	S	0.25-0.50	2.1-4.0	> 24 hr	
Road tars										
RT-3 to RT-6; RTCB-5 and RTCB-6	Liquid	Admix	Gravel to clay of moderate plasticity	M	V	M	0.30-0.50	2.5-4.0	Several days	Used in manner similar to asphalts; penetration is generally better than that of asphalts
RT-1 to RT-6; RTCB-5 and RTCB-6	Liquid	Penetration	Gravel to silty sand	M	V	S	0.25-0.50	2.1-4.0	Several days	
Emulsified asphalts										
Anionic										
SS-1 or SS-1h	Liquid	Penetration	Gravel to silty sand	M	V	S	0.10-0.50 (diluted)	0.8-4.0	Several hr	Requires careful control for proper emulsion break; can be diluted with water in varying proportions, with 3:1 water-to-emulsion generally satisfactory
		Admix	Gravel to silty sand	M	V	M	0.10-0.50 (diluted)	0.8-4.0	Several hr	
MS-2	Liquid	Admix	Gravel to coarse sand	M	V	M	0.10-0.50 (diluted)	0.8-4.0	Several hr	
Cationic										
SS-K or SS-Kh	Liquid	Penetration	Gravel to silty sand	M	V	S	0.10-0.50 (diluted)	0.8-4.0	Several hr	Cationic emulsions have somewhat broader application than anionic forms, but must be used with greater care
		Admix	Gravel to silty sand	M	V	M	0.10-0.50 (diluted)	0.8-4.0	Several hr	
SM-K	Liquid	Admix	Coarse to fine sand	M	V	M	0.10-0.30 (diluted)	0.8-2.4	Several hr	
CM-K	Liquid	Admix	Gravel to coarse sand	M	V	M	0.10-0.30 (diluted)	0.8-2.4	Several hr	
Special asphalts										
Product A††	Liquid	Penetration	Gravel to clay of moderate plasticity	M	V	M	0.25-0.50	2.1-4.0	4-8 hr	Excellent penetration ability; requires heating for spraying
Group II: Cementing Material										
Portland cement	Powder	Admix	All	S	S	S	--	1.5-4.0	12-24 hr	Normally used for strength, but will also provide modest benefits for dust control and waterproofing when used in small quantities as a soil modifier
Lime (hydrated)	Powder	Admix	Clays of moderate to high plasticity	S	S	S	--	1.5-4.0	12-24 hr	(Same as cement above)

(Continued)

* Sources of materials and approximate costs are given in table 2.
** Relative degree of effectiveness is indicated as follows: S = slight, M = moderate, V = very, X = applicable but effectiveness unknown, Blank = not applicable.
† For all admixture treatments, the quantities indicated are for a 1-in. depth of treatment and assume a compacted dry density of 100 lb per cu ft.
†† Proprietary material.

Table 1 (Concluded)

Materials (1)	Form of Material (2)	Acceptable Application Method(s) (3)	Applicable Soil Range (4)	Primary Function, Area of Use, and Degree of Effectiveness: Dust Palliative: Traffic (5)	Dust Palliative: Non-traffic (6)	Waterproofer (Traffic Area Only) (7)	Quantity Requirements: gal per sq yd (8)	Quantity Requirements: lb per sq yd (9)	Minimum Curing Time (10)	Remarks (11)
				Group III: Resin Systems						
Lignin	Liquid or powder	Admix	Sand to clay of low plasticity	S	S	S	--	4.0- 8.0	12-24 hr	Benefits may be only temporary, since resin is water-soluble
		Penetration	Sand to silty sand	X	X	X	0.50-1.0	4.0- 8.0	2-6 hr	
Product B††	Liquid	Penetration	Sand to clay of low plasticity	M	V	--	0.5 -1.5	4.2-12.5	0	Water required for dilution; 4:1 to 10:1 water to Product B may be used; not effective for soils of high iron oxide content
Concrete curing compound (with paraffin base resin)	Liquid	Penetration	Silts to clays of high plasticity	S	M	X	0.1 -0.2	1.0- 2.0	4 hr	Fairly viscous; requires special spray nozzles; forms thin, moderately flexible film on surface when cured; curing depends on temperature and humidity
				Group IV: Salts						
Sodium chloride	Granules	Admix	Gravel to silt (with fines present)	S	S	--	--	0.4- 0.8	0	All salts are corrosive to metal; subject to leaching; rely on absorption of moisture from air to palliate dust; brine solution forms surface crust
Calcium chloride	Powder or flakes	Admix	Gravel to silt (with fines present)	S	S	--	--	0.4- 0.8	0	
Brine solution	Liquid	Penetration	Sand to clay of low plasticity	S	S	--	0.5 -1.5 (20% solution)		0	
				Group V: Miscellaneous Materials						
Water	Liquid	Penetration	All	S	S	--	(As needed)		0	Temporary measure only
Various oils	Liquid	Penetration	All	S	X	--	0.25-1.0		0	Temporary measure only; may require frequent application

†† Proprietary material.

Table 2

Sources and Approximate Costs of Treatment Materials

Material	Source	Approximate Cost*
Cutback asphalts (all grades)	Most petroleum firms, refineries, and some local outlets	$0.15 per gal
Road tars	Tar refineries and local outlets	$0.20 per gal
Emulsified asphalts	Petroleum firms	$0.15 per gal
Product A	Proprietary product	$0.20 per gal
Portland cement	Local availability	$0.01 to 0.02 per lb
Lime	Local availability	$0.01 or less per lb
Lignin	Pulp wood processing plants	< $0.05 per lb
Product B	Proprietary product	$0.36 per gal
Concrete curing compound	Local availability	$0.60 to 0.90 per gal
Sodium chloride	Local availability	< $0.01 per lb
Calcium chloride	Local availability	< $0.01 per lb

* Purchase price indicated for liquids is generally for 55-gal-drum lots rather than bulk quantities. In the case of solids, the prices are for bagged quantities of 100 lb or less. Prices do not include shipping costs.

Table 3

Recommended Widths for Dust Control Treated Areas Adjacent to Traffic Areas

Using Aircraft	Maximum Effort Control: Runway Shoulder* ft	Maximum Effort Control: Taxiway Shoulder ft	Minimum Effort Control: Runway Shoulder* ft	Minimum Effort Control: Taxiway Shoulder ft
C-133	80	40	40	20
C-141	75	40	40	20
C-124	70	35	35	20
C-130	60	30	30	15
C-135	55	30	30	15
C-123	50	25	25	15
CV-2	40	20	20	15
CV-7	40	20	20	15
OV-1	20	20	15	15
O-1	20	20	15	15
F-4C	20	20	15	15
F-101	20	20	15	15
F-102	20	20	15	15
F-104	20	20	15	15
F-105	20	20	15	15

* Widths indicated for runway shoulders are applicable also to areas adjacent to overruns and parking aprons.

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This manual provides interim guidance to military engineering personnel in selecting and using materials for alleviating dust and for waterproofing soils in support of operations on expedient airfields and roads in the theater of operations. The problems of dust and water pertinent to military operations on unsurfaced airfields and roads are defined, and the objectives and limitations of soil surface treatments to alleviate these problems are stated. General procedures for applying a dust palliative or soil waterproofer are outlined, and the implications of these procedures to the ultimate selection of a material are presented. Various types of materials for treating soil surfaces to control dust and/or waterproof soil are described. Criteria to aid in the selection and use of a material, and various factors which may influence the final choice of a material are presented.

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