MISCELLANEOUS PAPER S-72-14

ENGINEER DESIGN TESTS OF DUST-CONTROL MATERIALS AND EMPLACEMENT EQUIPMENT

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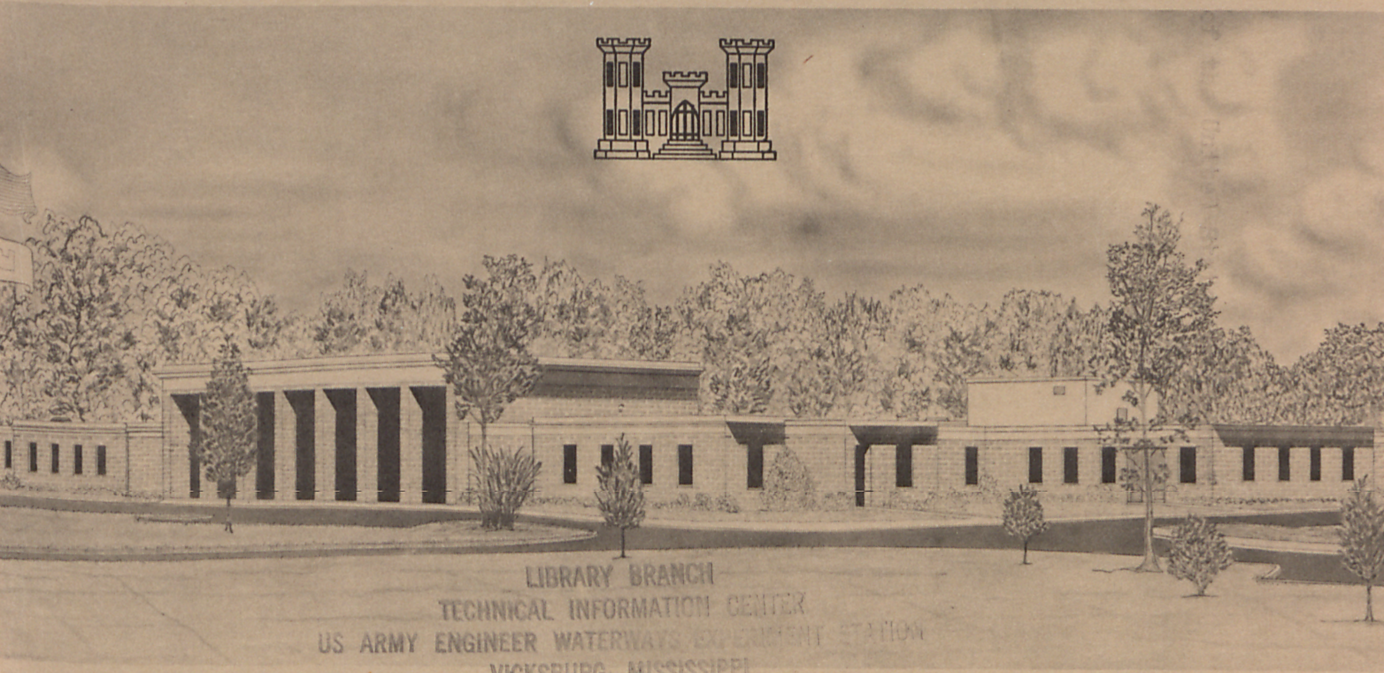
M. M. Culpepper, W. A. Wilvert



June 1972

Sponsored by U. S. Army Materiel Command

Conducted by U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi
and
U. S. Army Mobility Equipment Research and Development Center
Fort Belvoir, Virginia

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ARMY-MRC VICKSBURG, MISS.

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FOREWORD

The engineer design tests reported herein were conducted by personnel of the U. S. Army Engineer Waterways Experiment Station (WES) and the U. S. Army Mobility Equipment Research and Development Center (MERDC) under Research and Development Project No. 1G664717DH01, Task 12, "Dust-Control Material," and Task 13, "Liquid Distributor for Dust Control," under the sponsorship of the U. S. Army Materiel Command.

The tests were conducted during the summer of 1969 at Eglin AFB, Fla., and Ft. Benning, Ga., by personnel of the Expedient Surfaces Branch, Pavement Research Laboratory, Soils Division, WES, and Construction and Maintenance Equipment Branch, Mechanical Equipment Division, Mechanical Technology Laboratory, MERDC. The data generated by this study were reported to the sponsor; this report was published in order to provide a permanent record of the test results.

Engineers who were actively engaged in the planning, testing, analyzing, and reporting phases of this investigation were Messrs. J. P. Sale, Chief, Soils Division, R. G. Ahlvin, W. L. McInnis, R. C. Eaves, G. W. Leese, and M. M. Culpepper, all of WES, and Messrs. M. H. Henderson, A. J. Rutherford, W. H. Leathers, D. L. Craft, and W. A. Wilvert of MERDC. This report was written by Messrs. Culpepper and Wilvert.

COL Ernest D. Peixotto, CE, was Director of WES during preparation of this report. Mr. F. R. Brown was Technical Director. COL Bennett L. Lewis, CE, was Commanding Officer of MERDC. Mr. W. B. Taylor was Technical Director.

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CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
square yards	0.836127	square meters
feet per minute	0.3048	meters per minute
cubic feet per minute	0.0283168	cubic meters per minute
gallons (U. S.)	3.785412	cubic decimeters
pounds	0.45359237	kilograms
tons	907.185	kilograms
gallons per minute	3.785412	cubic decimeters per minute
pounds per square inch	0.6894757	newtons per square centimeter
pounds per square foot	47.88026	newtons per square meter
horsepower	754.700	watts
acres	4046.856	square meters

SUMMARY

This report describes and presents the results of engineer design tests (EDT) of two dust-control materials, a polyvinyl acetate (PVA) water emulsion and a cationic asphalt-neoprene emulsion (CANE), and two distributors, one pneumatic and one mechanical, that were used to apply the PVA and CANE. Both distributors were used to apply the PVA and CANE with no reinforcing, with fiberglass scrim reinforcing, and with prechopped fiberglass reinforcing to sand and clay soils in an intermediate climate. The materials were allowed to cure for 4 hr after placement and were then subjected to the simulated airblast of a CH-47 helicopter and a C-130 aircraft and to traffic by 1/4- and 2-1/2-ton vehicles. Only minor deficiencies in the PVA and CANE, i.e., instability in storage, excessive runoff, and tackiness after 4 hr curing time, were observed during testing. The pneumatic distributor sprayed both materials with ease, but the mechanical distributor encountered difficulty in spraying the CANE.

Based on the results of the investigation reported herein, the following recommendations are considered warranted:

- a. Action should be initiated to correct the deficiencies in PVA and CANE.
- b. Fiberglass scrim should be used as reinforcing material until equipment capable of placing prechopped fiberglass at the required rates and in the required quantities can be devised and developed.
- c. Investigations for improving the distributor pump should be continued.
- d. All edges of film-forming dust-control materials that may be exposed to blast should be anchored by burying.
- e. Film-forming dust-control materials that are to be subjected to traffic should be reinforced.

ENGINEER DESIGN TESTS OF DUST-CONTROL MATERIALS AND EMPLACEMENT EQUIPMENT

PART I: INTRODUCTION

Background

1. There currently exists a Department of the Army approved Qualitative Materiel Requirement for development of an effective dust-control system consisting of materials and placement equipment to be used in support of military operations. In response to this requirement, the U. S. Army Engineer Waterways Experiment Station (WES) and U. S. Army Mobility Equipment Research and Development Center (MERDC) have conducted extensive research and development programs to establish new and improved materials and placement equipment for dust control.

2. During the summer of 1967, six commercial dust-control materials (three film formers and three penetrants) were subjected to an integrated engineering and service test. None of the items tested met all of the requirements for an acceptable dust-control material as stated in a U. S. Army Materiel Command letter dated 21 June 1967.* During the summer of 1968, two new film-forming dust-control materials that were developed under contract were subjected to a military potential test (MPT) at Yuma Proving Ground (YPG), Arizona. In addition to the two new materials, one of the previously tested film-forming materials was included in the MPT as a comparison item. Each material was placed at various application rates both with and without fiberglass reinforcing. The comparison item, a proprietary polyvinyl acetate (PVA) water emulsion, and one of the contract-developed items, a cationic asphalt-neoprene emulsion (CANE), showed sufficient potential as

* Letter dated 21 June 1967 to Director, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., from AMC, Subject: Equipment Performance Reports of USATECOM Project No. 7-7-0888-01-02.

dust-control materials to warrant further development and testing.*

3. The MERDC supplied three different distributors as application equipment (two gear pump and one pneumatic) and monitored emplacement operations in the field during the MPT at Yuma. All equipment items were generally capable of applying the dust-control materials; however, only two of the distributors (one gear pump and one pneumatic) were judged to have sufficient potential to warrant further development. These two distributors were subsequently modified to correct certain deficiencies encountered during the MPT and were equipped to emplace liquid palliative either with or without fiberglass reinforcing.

4. Based on the results of the MPT, WES and MERDC recommended that engineer design tests (EDT) be conducted at two locations during the summer of 1969. The additional tests were necessary to establish performance characteristics of the dust-control materials for soil types and environmental conditions other than those encountered at YPG, to obtain additional design data, to evaluate equipment improvements, and to evaluate various means of applying fiberglass reinforcing.

5. Eglin AFB, Fla., and Ft. Benning, Ga., were chosen as test sites on the basis of the following criteria:

a. Environment different from that at YPG.

b. Clayey and sandy soils to simulate soil conditions in the Southeast Asia (SEA) theater of operations.

c. Test and maneuvering areas that would be sufficiently large and would require a minimum of construction effort.

Test Objectives

6. Specific objectives of the EDT's were to:

a. Determine the effectiveness of PVA emulsion and CANE, applied both with and without fiberglass reinforcing, in controlling dust on sand and clay soils under intermediate climatic conditions.

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* L. W. Murdoch and A. J. Faggion, Jr., "Military Potential Test of Dust Control Materials," 28 Feb 1969, U. S. Army Armor and Engineer Board, Ft. Knox, Ky., and U. S. Army General Equipment Test Activity, Ft. Lee, Va.

b. Establish the suitability of prechopped fiberglass and prefabricated scrim as reinforcing for the basic liquid dust-control materials.

c. Evaluate methods developed for preparing a suitable transition joint between a metal landing-mat-surfaced runway and a treated shoulder area.

d. Examine techniques of anchoring edges of surface films.

e. Evaluate capabilities of modified application equipment to emplace the dust-control materials both with and without fiberglass reinforcing.

f. Obtain additional data for design of a prototype universal liquid distributor.

g. Enhance existing information pertinent to optimization of application rates and techniques of handling and emplacement.

Scope

7. These EDT's were performed to evaluate PVA and CANE applied with and without chopped fiberglass or fiberglass scrim reinforcing. Two types of modified application equipment (mechanical and pneumatic) were used to apply the dust-control materials. The various surfaces were evaluated under simulated CH-47 helicopter and C-130 aircraft air-impingement conditions that were attained by use of a helicopter downwash simulator and a WES-developed aircraft blast simulator. The dust-control materials were also placed on a roadway section and evaluated under the traffic of wheeled vehicles.

PART II: DESCRIPTIONS OF MATERIALS AND EQUIPMENT

8. Descriptions of the basic dust-control materials, fiberglass reinforcing, and application equipment are presented in the following paragraphs. For ease of reference, the PVA and CANE will hereinafter be referred to as materials A and B, respectively.

Dust-Control Materials

Material A

9. Material A is a commercially available item, consisting of a PVA emulsion modified with plasticizers, surfactants, and other inorganic elements. Upon cure, the material forms a highly flexible film possessing good elongation and tensile strength properties. For this investigation, material A was diluted for application at a rate of two parts concentrate to one part water. This material is stable in controlled storage for up to three years.

Material B

10. Material B, a contract-developed item, is a cationic asphalt-neoprene blend in a water emulsion form consisting of a propane precipitated and oxidized asphalt, a neoprene latex, and a wetting agent. Material B is applied as supplied. This material is unstable in storage.

Fiberglass reinforcing

11. Prechopped strands. A continuous-strand fiberglass was prechopped at the factory into 2-in.* lengths and packaged in cardboard containers, each containing approximately 30 lb of the strands.

12. Scrim. The scrim used was an open-weave fiberglass fabric. Many weave patterns, widths, weights, and finishes are available. The scrim used in this program was Style No. 1659, leno weave, 10 by 10 weave pattern, and had a greige finish.

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* A table of factors for converting British units of measurement to metric units is presented on page ix.

Disk-type anchors

13. Anchors were used at Eglin AFB to prevent blast-induced displacement of the dust-control materials. Each anchor consisted of an 8-in.-diam by 1/8-in.-thick dome-shaped, steel plate head to which was welded a 24-in.-long, 3/4-in.-diam reinforcing rod shaft pointed at the driving end.

Emplacement Equipment

14. The dust-control material emplacement equipment utilized in the field tests consisted of one mechanical and one pneumatic distributor, a mulcher for emplacing prechopped fiberglass strands, and an experimental shaker-roller apparatus for emplacing prechopped fiberglass strands. Descriptions of these equipment items follow.

Mechanical distributor

15. An Etnyre 1500-gal-capacity commercial asphalt distributor* was modified to simultaneously emplace fiberglass scrim for reinforcing, water for prewetting soil, and dust-control materials (fig. 1). The

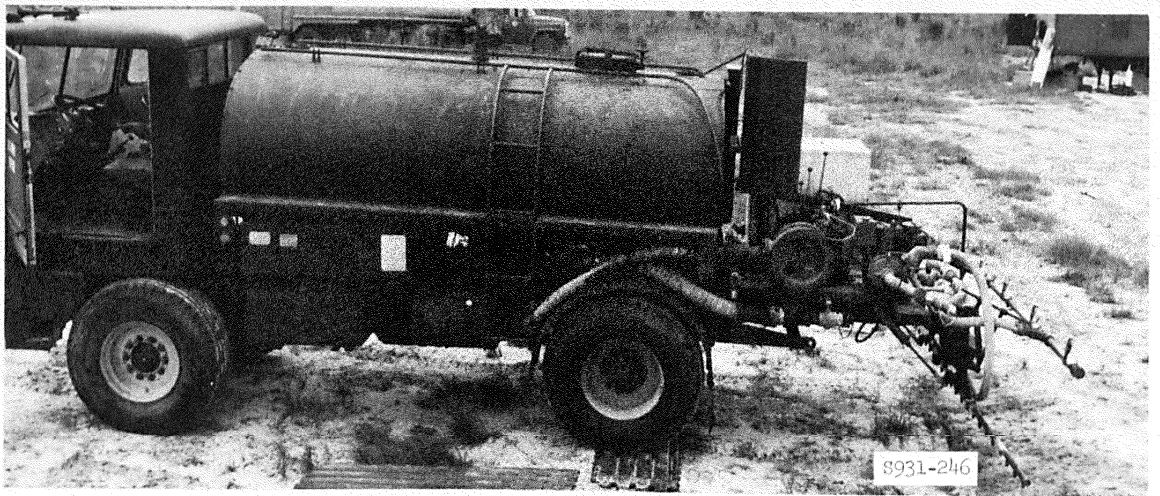

Fig. 1. Mechanical distributor

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* This distributor is capable of placing asphalt, road oils, water, etc., as well as emulsions.

original asphalt pump, pump transmission, external piping system, internal tank piping, and asphalt heating system were removed. The chassis frame was extended 24 in. to facilitate mounting of a hydraulic pump drive motor, a standard jeep transmission with transfer case, and a cast-iron Viking Model 124 pump rated at 300 gpm at 300 rpm. An aluminum water tank (36 by 30 by 36 in.) and a gasoline-engine-driven Marlow Model 21-1/2 C155 water pump were mounted on the same extension. The scrim emplacement attachment, the water spray bar, and the emulsion spray bar were suspended from the extended frame (fig. 2). The experimental shaker-roller dispenser could be suspended from the frame after

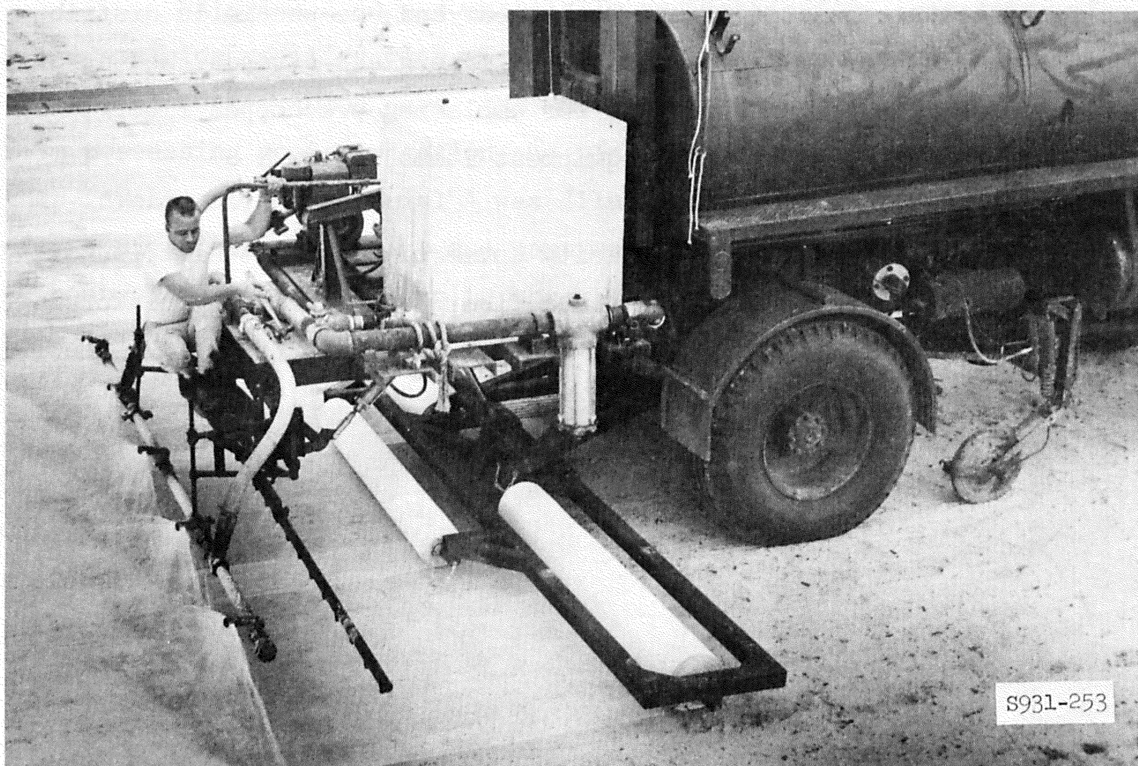

Fig. 2. Mechanical distributor with scrim emplacement attachment, water spray bar, and emulsion spray bar in place

removal of the scrim attachment. An air-operated pressure manometer manufactured by King Gage Company was installed to measure the liquid level in the material tank. A float-type gage with a graduated sight rod was installed within the water prewet tank to measure the liquid level there. Quick-opening two-way ball and butterfly valves and wire-reinforced hoses with quick-connect fittings were used in the plumbing and distribution system. The original tires on the distributor truck were replaced with four 18x22.5 sand tires to minimize rutting.

16. The scrim emplacement attachment was a fabricated steel box-channel frame on which three 6-ft-wide fiberglass scrim rolls were mounted in a triangular configuration, i.e. with two of the rolls leading a center trailing roll (see fig. 2). The center roll overlapped the inside edges of the leading rolls 1 ft. Thus, a 16-ft-wide strip was produced when the scrim was unrolled. The scrim frame was equipped with an air cylinder attached to the center member of the frame to provide a means of raising the assembly for transport or lowering it for scrim application. As the vehicle moved forward, the scrim unrolled onto the ground surface.

17. The prewetting water spray bar was a 16-ft-long by 1-1/2-in.-diam copper tube with one inlet connection. Twenty-four Spraying Systems Company Model N-26 fog-jet nozzles were equally spaced on the bar. The spray bar could be adjusted up or down manually by use of a screw-type mechanism.

18. The emulsion spray bar was a 2-in.-diam stainless steel tube provided with two inlet connections. Five equally spaced Spraying Systems Company Model 3/4 K-210 nozzles, each angled to obtain 50 percent spray overlap, sprayed the emulsion across the 16-ft span. This spray bar was suspended from the chassis aft of the water spray bar by pivoted hangers attached to two air cylinders, which were used to raise the bar during maneuvering.

19. Schematic flow diagrams of the emulsion and water supply systems for the mechanical distributor are shown in plate 1.

Pneumatic distributor

20. The pneumatic distributor (fig. 3), designed and fabricated by MERDC, was tested to determine its capability for emplacing dust-control materials. The chassis was a tandem-axle, heavy-equipment transport trailer with four 18x22.5 sand tires. A standard Army 5-ton dump truck was used as a prime mover. An 800-gal-capacity pressurized emulsion supply tank was saddle-mounted in the geometrical center of the trailer bed.

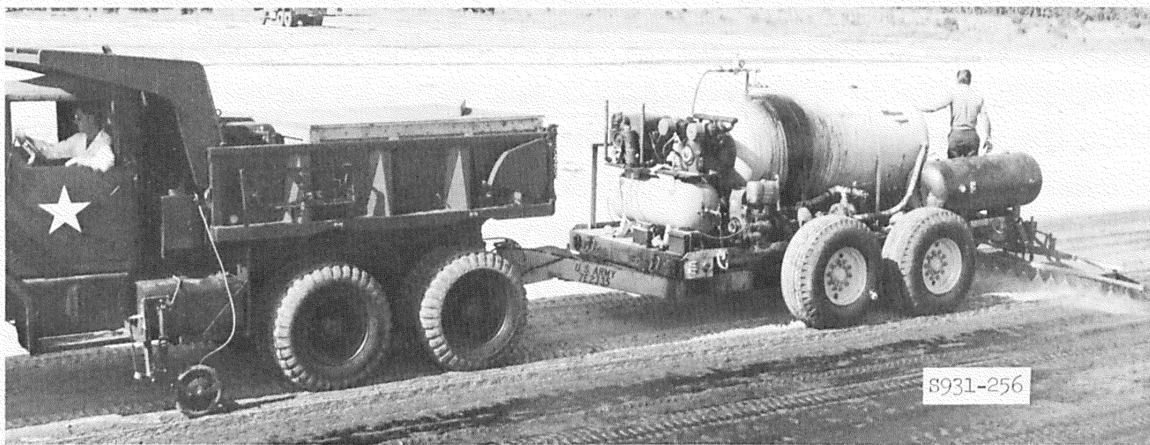

Fig. 3. Pneumatic distributor

Liquid level was indicated by a King Gage pressure manometer. A WABCO 80-cfm air compressor, belt-driven by a 20-hp standard military engine, supplied air to an 80-gal-capacity air receiver at 100 psig. The engine and compressor straddled the air receiver, which was mounted on the forward end of the trailer. A skid-mounted pumping unit for charging and circulating emulsion in the tank was mounted on the left front end of the trailer. This unit included a single-cylinder 12.5-hp gasoline engine, a Dodge friction clutch, a Dodge 4.5-to-1 ratio reduction gear, and a Viking Model L-124 pump rated at 90 gpm at 400 rpm. A 125-gal-capacity water supply tank was mounted at the left rear corner of the trailer. An additional 80-gal-capacity air receiver was mounted on the right rear corner of the trailer to store a reserve quantity of air at 100 psig to ensure completion of the spraying operation in case of compressor loss during a run. Quick-opening two-way ball and butterfly valves were used in the emulsion plumbing and distribution system.

21. Three 6-ft-wide scrim rolls were suspended (one forward and two trailing) from the trailer bed by use of free-swinging pivoted hangers. The rolls were arranged to lay a 16-ft-wide strip and to provide a 1-ft overlap of each fiberglass scrim roll. When two ball bearing hubs were inserted into both ends of each roll and secured to the hangers, the rolls were suspended approximately 3 in. above the ground. This was the maximum suspension possible because of the 28-in. ground

clearance of the trailer bed. Emplacement was accomplished by weighting the free end of the scrim, which unrolled as the trailer moved forward during the spraying operation.

22. The water spray bar, mounted aft of the scrim rolls, was suspended from the trailer bed by use of pivoted hangers and was similar to that on the mechanical distributor.

23. The pneumatic distributor's emulsion spray arrangement differed slightly from the mechanical distributor's spray arrangement. The five equally spaced Spraying Systems Company Model 3/4 K-210 nozzles, angled to obtain 50 percent overlap of each spray pattern, were attached to a 3-in. aluminum channel. The nozzles were separately connected by 3/4-in.-ID industrial hoses to a 6-in.-diam manifold secured to the center of the aluminum channel. The manifold received its supply through a 3-in.-ID industrial hose. The assembly was supported by arms that were pivot-mounted on the rear corners of the trailer. Two air cylinders raised the assembly for maneuvering.

24. A schematic flow diagram of the emulsion and water supply system for the pneumatic distributor is shown in plate 2.

Mulcher

25. A Finn Manufacturing Company Model BMS 19 mulcher (fig. 4) was obtained and modified to emplace prechopped fiberglass strands.

Fig. 4. Modified mulcher

Modifications were made by adding additional fingers to the endless chain belt feed, adding additional beater chains, and extending and enlarging the feedbox. The fiberglass strands were hand-fed to the belt and passed through rotating mulching chains and then through a blower that discharged them through a nozzle. The equipment operator controlled direction of discharge. This assembly was mounted on a two-wheel pneumatic-tired dolly and was towed by a military jeep.

Experimental shaker-roller
fiberglass strand dispenser

26. An experimental shaker-roller dispenser was designed as an attachment for the mechanical distributor to allow emplacement of pre-chopped fiberglass strands simultaneously with the spraying operation. The dispenser (shown in fig. 5), which comprised two rectangular bins

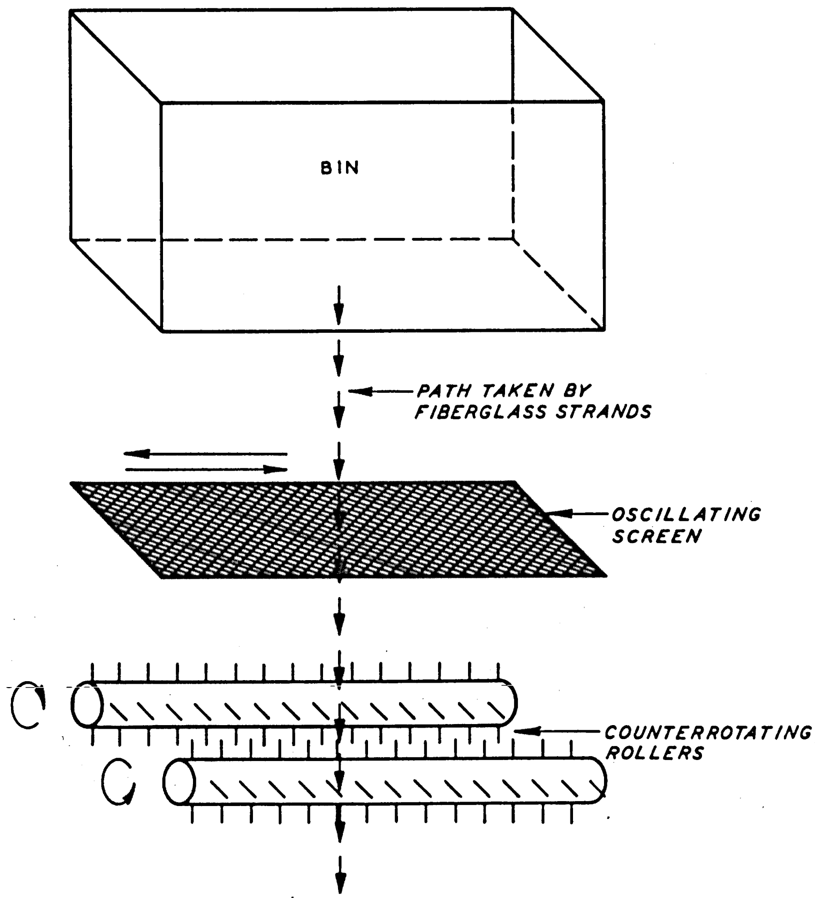

Fig. 5. Schematic of one bin and shaker-roller apparatus

suspended from the rear of the mechanical distributor, spread prechopped fiberglass strands over a span of 16 ft. Each bin was equipped at the bottom with an oscillating screen and two counterrotating rollers containing short metal fingers. Power was supplied by a 10-hp gasoline engine.

Test Equipment

Helicopter downwash simulator

27. The helicopter downwash simulator is a fan machine mounted on the rear of a 5-ton 6x6 truck (fig. 6). The blade diameter is 15 ft.

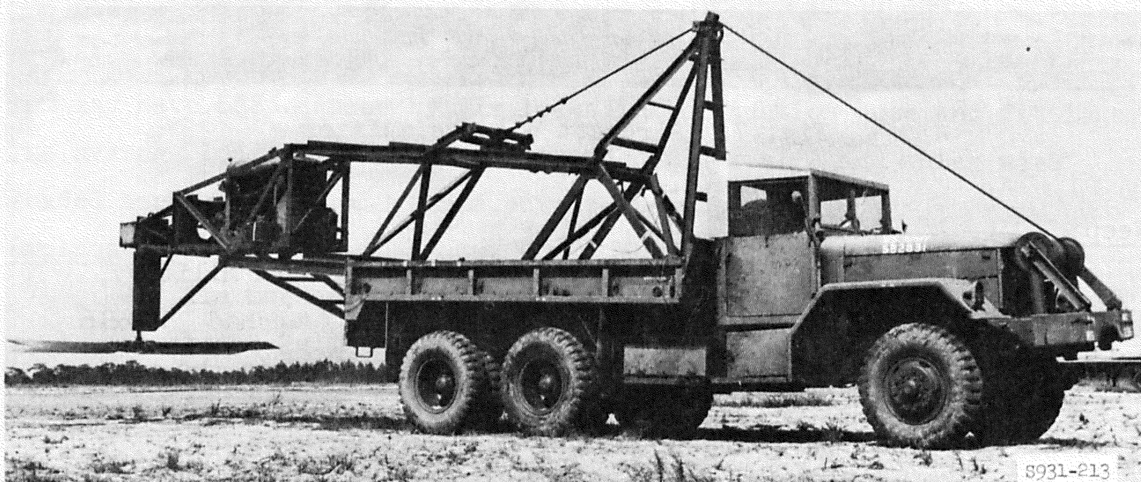

Fig. 6. Helicopter downwash simulator

The simulator produces a disk load of 6.04 psf at 500 rpm. When the blades were positioned 3.6 ft above the test surface, an air velocity of 2310 fpm was measured at ground level 7.5 ft from the outer edges of the blades.

Aircraft blast simulator

28. The aircraft blast simulator is a trailer-mounted C-130 aircraft engine (fig. 7). The engine (model A) is oriented in the same position in relation to the ground as the engine on a taxiing C-130 aircraft. Air velocities at various distances behind this engine are shown in plate 3.

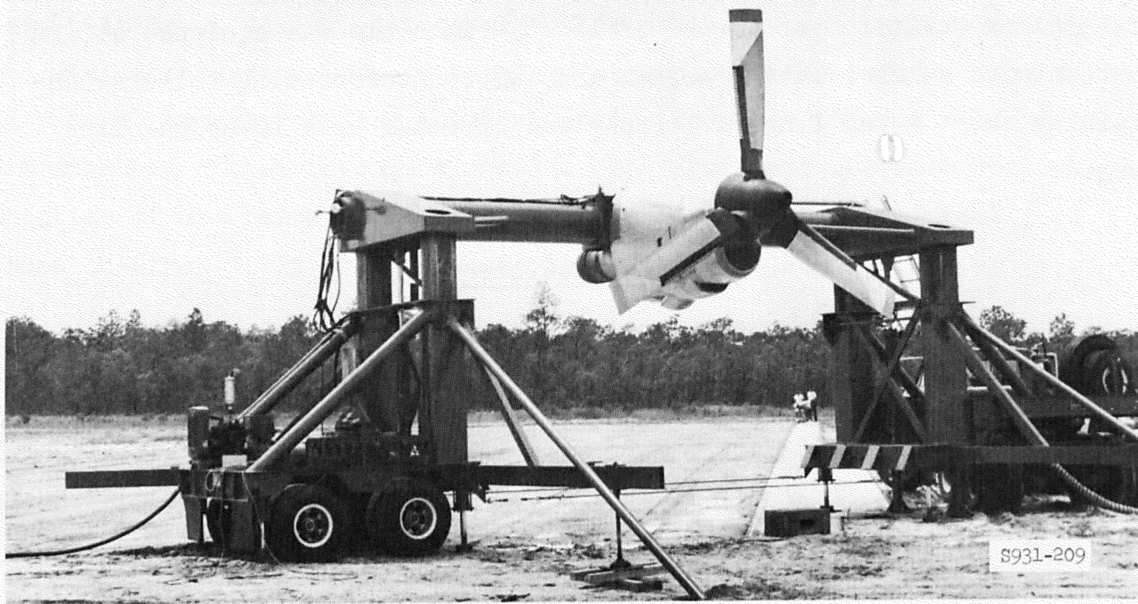

Fig. 7. Aircraft blast simulator

Jeep

29. The jeep used in traffic tests was a standard military, 1/4-ton, 4x4, having a net weight of 2273 lb. The jeep had 7.00x16 tires inflated to 18 psi in the front tires and 22 psi in the rear tires.

Truck

30. The truck used in traffic tests was a commercial 2-1/2-ton, 2x4 vehicle, with rear dual wheels, having a net weight of 22,000 lb. The truck had 8.25x20 tires inflated to 70 psi.

PART III: EQUIPMENT OPERATION AND PERFORMANCE

Mechanical Distributor

Loading

31. The material was loaded into the distributor tank from 55-gal open-top drums by use of the distributor pump and a 4-in.-diam suction hose. A minimum of four people were actively engaged in the loading operation. During loading, the pump was run at all times, and the suction hose was manually transferred from drum to drum. No problems were encountered during the loading cycle except that on a few occasions the pump was slow in priming. This was particularly true with material A, which was the more viscous of the two materials. Some of the problem may have been caused by air leaks in the suction hose and fittings. The average loading rate was 55 gpm when material A and water were loaded separately at a 2:1 concentrate to water ratio.

Emplacement

32. The mechanical distributor emplaced all of material A (4359 gal) used at the Eglin AFB site. It was intended that this distributor be used to emplace all of material B at the Ft. Benning site; however, failure of the pump transmission during the early phase of the tests at Ft. Benning necessitated alterations in this plan. Prior to the transmission failure, the mechanical distributor emplaced 815 gal of material B. After replacement of the transmission, the distributor emplaced 2414 gal of material A.

33. Uniform emplacement of the materials was achieved, and rates of application were within acceptable tolerances at Eglin AFB and Ft. Benning. There was no instance of valve sticking or nozzle clogging with either material. Spraying the normal 16-ft spray width was a problem, because, on subsequent passes, the distributor tires picked up the sprayed materials.

34. The scrim emplacement attachment was relatively trouble free except that dirt got into the sleeve bearings and reduced the smooth rolling capabilities. Mounting the scrim attachment to the distributor

and attaching the scrim rolls to the attachment frame presented no problems. The scrim was cut with a pocketknife at the end of each pass.

35. The emulsion pump was relatively successful in recirculating and pumping material A. In order to keep the pump operational, it was lubricated through grease fittings during each fill cycle. Toward the end of the tests at Ft. Benning, the lubrication passage in the front rotor bushing clogged with material A, which prevented further lubrication of the front bearing. Also, spasmodic rotation indicated that the pump was difficult to start after short interruptions of pumping operations. This problem was caused by material A getting into the idler bearing and curing. Material A was also quite corrosive to the cast-iron pump.

36. Since only approximately 815 gal of material B had been emplaced at the time of the transmission failure, it was not possible to fully evaluate the ability of the pumping system of the mechanical distributor to pump material B. However, limited field experience has shown that material B is considerably more difficult to pump and emplace than material A.

37. The transmission failure is believed to have been caused by buildup of material B in the pump. The hydraulic pump discharge hose failed on two occasions because of a defective hose fitting.

Cleaning

38. During the field tests, the mechanical distributor tank, pump, and spraying system were cleaned at the end of each day of operation. Equipment cleaning procedures for each material were as follows:

a. Material A. Water was added to the remaining material in the tank and circulated from 5 to 10 min before being discharged through the spray bar and nozzles. Additional water was then added to the tank and discharged through the spray bar and nozzles until the discharge was clear. The nozzles were cleaned occasionally during inactive periods by peeling and scraping the dried material from the curved deflectors.

b. Material B. Cleaning was accomplished by flushing the residue out of the tank, pump, and spraying system with water. The remaining material was washed out by circulating a solvent (JP-4) through the spraying system. Water was again used to flush the system after use of the solvent.

Pneumatic Distributor

Loading

39. The material tank was loaded by pumping the material from 55-gal open-top drums through a 3-in.-diam suction hose with the distribution pump. A 1/4-in.-mesh wire, basket-shaped strainer was inserted into the drums of material B to filter out the large solid particles. A minimum of four people were actively engaged in the loading operation. During loading, the pump was run at all times and the suction hose was manually transferred from drum to drum. No problems were encountered during loading except that occasionally the pump slowed and operation became laborious. During loading, the pump shaft grease fittings were continuously lubricated with a grease gun. The average loading rate for material B was 42 gpm. After each loading operation, the pump was flushed out with water.

Emplacement

40. The pneumatic distributor emplaced all of material B (4747 gal) at Eglin and 3096 gal of material B and 2414 gal of material A at Ft. Benning. Failure of the emulsion pump transmission on the mechanical distributor made it necessary to utilize the pneumatic distributor for both materials in order to expedite completion of the Ft. Benning tests.

41. Uniform emplacement and acceptable application rates were maintained throughout the tests.

42. The free-rolling, suspension-type scrim attachment on the pneumatic distributor laid a much looser in-place material than the attachment on the mechanical distributor. The loose material emplaced by the pneumatic distributor followed the ground contour slightly better than the tight material emplaced by the mechanical distributor, but other emplacement problems were encountered. For example, wind caused the scrim edges to fold back, thus leaving some areas uncovered. Similarly, the striking force and angle of the emulsion spray washed the edges back, again leaving areas uncovered.

43. The Viking Model L-124 pump used for loading and recirculating materials A and B presented no major problems except that it required constant lubrication and cleaning to continue functioning satisfactorily when applying material B.

Cleaning

44. During the field tests, the pneumatic distributor tank, pump, and spraying system were cleaned at the completion of each day of operation. In addition the pump was flushed with water after each loading operation. Equipment cleaning procedures for material A were the same as those used with the mechanical distributor (see paragraph 38a). For material B, the distributor tank was partially filled with JP-4, which was circulated to flush residue out of the tank and pump, and discharged through the spraying system. The tank was then filled with water, which was circulated through the tank and pump and then discharged through the spray bar and nozzles until the discharge was clear.

Mulcher

45. Two operators, in addition to the jeep driver, were required to operate the mulcher. One operator fed the prechopped fiberglass strands into the machine, and the other directed the cylindrical chute in the desired direction. Rate and uniformity of application were judged by the appearance of the fiberglass on the ground.

46. At Eglin, the mulcher was used to emplace all of the prechopped fiberglass, and at Ft. Benning, it was used to emplace all but one test section. Numerous problems were encountered in emplacing prechopped fiberglass with the mulcher. Friction of the strands apparently created a static electrical charge that caused the strands to build up along the sides of the feed bin's entrance to the blower. Large matlike masses of fiberglass were continuously discharged from the chute; also, many strands were blown off course by the wind. All of these problems resulted in uncontrollable and nonuniform emplacement. The rate of coverage was very slow, averaging approximately 14 sq yd per min. Attempts to increase the emplacement rate by faster feeding

resulted in an even less uniform discharge and in more large matlike masses of fiberglass.

Experimental Shaker-Roller Fiberglass Strand Dispenser

47. An experimental fiberglass dispenser was designed and fabricated by MERDC and mounted on the mechanical distributor during the final week of testing at Ft. Benning for evaluation. Initial check-out of the dispenser showed that the fiberglass would not feed through the oscillating screen. Close investigation revealed that the prechopped fiberglass strands were stiffer and larger in diameter than the strands used by MERDC to develop the dispenser. Weights were placed on top of the fiberglass in the bins in an attempt to improve the feed. This resulted in unrepairable damage to half of the dispenser when the screen in one bin became deformed to the point of contacting the rotating rollers. Despite the failure, one section was emplaced using half of the dispenser. Application rates were uncontrolled and the mounted dispenser reduced the ground clearance and mobility of the distributor.

PART IV: FIELD TESTS AT EGLIN AFB, FLA.

Location and Layout

48. The test site was located on an airdrop zone within the reservation limits of Eglin AFB. The soil at the site was a poorly graded silty sand (SP-SM). Classification data and a gradation curve are given in plate 4. The climate at Eglin is considered to be intermediate.

49. A test section layout was adopted that was relatively easy to prepare, required a minimum quantity of dust-control materials, and provided 12 test sections of equal size and nature for blast tests and 6 test sections of equal size and nature for traffic tests. The dimensions of the test sections were governed by the testing equipment requirements. A layout of the test sections is shown in plate 5.

Preliminary Construction

50. The natural ground surface was relatively smooth and sloped sufficiently for good drainage. A motor grader was used to remove all vegetation, major surface irregularities, and large debris. Pramitol 25E herbicide was applied to the test sections at a rate of 2 gal per acre. Each test section was staked out, landing mat was placed along one edge to simulate a runway, and string lines were placed as guides for placing the dust-control materials.

Material A Test Sections

Application tests

51. The mechanical distributor was used to place prewetting water,* material A, and the fiberglass scrim reinforcing. On the two

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* Prewetting water was applied to the soil surface at rates of 0.05 to 0.1 gal/sq yd to relieve surface tension and to allow the dust-control emulsion to form a continuous film with few if any holes in the cured film.

sections requiring prechopped fiberglass reinforcing, the modified mulcher was used to place the fiberglass. A trench approximately 6 in. deep was cut by a motor grader along one of the 60-ft sides of each test section in order that the edge of the treatment could be buried and anchored. After the test materials had been placed on the test sections and in the trenches, the trenches were backfilled by the motor grader. Disk-type anchors were used along the edges of two of the reinforced sections. Table 1 presents a summary of the application rates, soil surface water content data, and test results for materials A and B.

52. All materials were placed in typical Florida summer weather, i.e. intermittent, bright sun followed by clouds and rain showers.

53. Prechopped fiberglass. Uniform coverage was not obtained because the individual strands of fiberglass bunched together, thus giving some areas a heavier concentration than others. In the areas of heavy application, the fiberglass strands supported each other and did not lie flat on the ground. The fiberglass was virtually impossible to place when damp. Material A hit the placed fiberglass with enough force and at such an angle that the fiberglass was forced into windrows, leaving nonreinforced areas.

54. Fiberglass scrim. The fiberglass scrim was placed simultaneously with the prewetting water and dust-control material. A very uniform coverage was obtained because the fabric was rolled onto the ground. However, major application problems became apparent. For example, occasionally, the edges of the scrim rolled up or folded over, leaving areas without any reinforcing (photo 1). Also, when the scrim was placed over roots or debris, tentlike areas were formed (photo 2).

55. Material A. Following the application of prewetting water, material A was placed by the mechanical distributor. Coverage was uniform except for minor "fisheyes"* (photo 3). Material A pumped and

---

* "Fisheyes" are small holes ranging in size from 1/4 to 1-1/2 in. in diameter that are formed in the dust-control emulsion almost instantaneously after application. Initially, complete soil coverage is obtained, but surface tension of the soil causes the emulsion not to adhere to the soil, thus causing the small random holes. The holes allow moisture to enter the soil and airblast to get under the dust-control film.

sprayed well. With one exception, material A cured completely in 4 hr even when rain fell during the cure time. When material A flowed into and ponded in ruts and depressions, a surface film was formed, leaving uncured material underneath. Curing times for these ponded areas were dependent upon their depths. At the transition joints between landing mats and treated sections, material A was first sprayed by the distributor. Then a 36-in.-wide roll of scrim was placed along each joint and a hand-held spray bar was used to coat this scrim with material A (photo 4).

Operational performance tests

56. These tests were conducted 4 hr after the materials had been placed. A brief summary of each type of test is presented below.

57. Helicopter downwash. The helicopter downwash simulator was backed over all anchored edges and one unanchored edge of each test section to simulate the approach of a helicopter to a landing pad. This test was to determine the resistance of the different edge preparations to lift caused by the downwash. The downwash impinged on each treated section for 1 min. No movement of any dust-control material was observed.

58. Aircraft blast. The C-130 airblast simulator was positioned so that the blast was directed down the center line of each treated test section. No movement of any dust-control material was observed. The treatment was deliberately cut perpendicular to the center line and retested with no failures occurring.

59. Vehicular traffic. All test sections were damaged by traffic, mainly where the vehicles crossed ruts created by distributor operation (photo 5). Traffic test results are given in table 1.

Material B Test Sections

Application tests

60. The pneumatic distributor was used to place the prewetting water, material B, and the fiberglass scrim reinforcing. Material B had to be strained prior to pumping. Otherwise, application test

preparation was the same as that for material A (see paragraph 51).

61. All materials were placed in typical Florida summer weather (see paragraph 52).

62. Prechopped fiberglass. Application of the prechopped fiberglass in the material B test sections was the same as that in the material A test sections (see paragraph 53).

63. Fiberglass scrim. Application of the fiberglass scrim in the material B test sections was the same as that in the material A test sections (see paragraph 54).

64. Material B. Following the application of prewetting water, material B was placed by the pneumatic distributor. Except for fisheyeing (photo 6), acceptable application rates and uniform coverage were obtained. The fisheyes were large and numerous enough to require that the atomizing prewetting water nozzles be replaced with larger capacity V-jet nozzles. Although this change helped, it did not eliminate all fisheyes. Material B hit the ground with enough force and at such an angle that it disturbed the prewetted soil. Material B cured in 4 hr but remained tacky (photo 7) until enough dust or sand covered the surface to blot the tacky material. Application on the transition joints was the same as that described for material A (see paragraph 55).

Operational performance tests

65. These tests were conducted 4 hr after the materials had been placed. A brief summary of each type of test is presented below.

66. Helicopter downwash. Tests were conducted as on the material A. Only the 3-lb-per-sq-yd section without reinforcing was damaged. A major failure occurred when the helicopter simulator pulled off the section to simulate a helicopter takeoff. An unanchored edge lifted, and the failure progressed into the test section.

67. Aircraft blast. The C-130 airblast simulator was positioned so that the blast was directed down the center line of each treated test section. No movement of any dust-control material was observed. The treatment was deliberately cut perpendicular to the center line and retested with no failures occurring.

68. Vehicular traffic. All test sections were damaged by traffic, mainly where the vehicles crossed ruts created by distributor operation (see photo 5). Traffic test results are given in table 1.

PART V: FIELD TESTS AT FT. BENNING, GA.

Location and Layout

69. The test site was located in an open field within the reservation limits of Ft. Benning, Ga. The soil at the site was lean and heavy clay (CL-CH). Classification data and a gradation range are given in plate 6. The climate is considered to be intermediate.

70. The test section layout was the same as the test section layout at Eglin AFB (plate 5).

Preliminary Construction

71. All construction at Ft. Benning was the same as that at Eglin except that use of the landing mats and disk-type anchors was discontinued.

Material A Test Sections

Application tests

72. The mechanical and pneumatic distributors were used to place prewetting water, fiberglass scrim, and material A. On the two test sections requiring prechopped fiberglass reinforcing, the modified mulcher and the experimental fiberglass strand dispenser were each used to place one section of the fiberglass. Table 1 presents a summary of the application rates, soil surface water content data, and test results for materials A and B.

73. All materials were placed in hot weather during which frequent rains occurred that kept the clay soil wet or moist.

74. Prechopped fiberglass. Good, uniform coverage was obtained by the experimental fiberglass strand dispenser on one test section. This piece of equipment literally tore itself up placing the one section. Uniform coverage (as obtained in the Eglin AFB test) was not obtained using the mulcher.

75. Fiberglass scrim. The application problems discussed in paragraph 54 for fiberglass scrim placement at Eglin also occurred at Ft. Benning.

76. Material A. Following the application of prewetting water, material A was placed by the pneumatic distributor on three test sections. Application rates were lower than desired. The remaining test sections were treated by the mechanical distributor. Again actual application rates were lower than desired except in one test section. All sections treated with material A at a rate of 5 lb/sq yd or greater had large amounts of runoff and ponding in depressions. Material A cured in 4 hr except in the ponded areas.

Operational performance tests

77. These tests were conducted 4 hr after the materials had been placed. A brief summary of each type of test is presented below.

78. Helicopter downwash. The procedure for conducting this test was identical with that used at Eglin AFB. During the test, the unanchored edge of one scrim-reinforced section lifted from the soil surface. Due to the arrangement of the spray nozzles, the outer edge of each strip of fiberglass scrim received only half as much of the dust-control material during each pass of the distributor as the interior portion of each strip. Succeeding passes were overlapped 1 ft, thus ensuring full coverage of all but the outermost edge of each test section. A good bond to the soil was not achieved on the outermost edge. Anchors were placed on 3-ft centers along the failed edge and the failed section was retested. No failures occurred during the retest.

79. Aircraft blast. The C-130 airblast simulator tests were conducted as at Eglin. No failures were observed.

80. Vehicular traffic. No failures were caused by trafficking with a 2-1/2-ton truck.

Material B Test Sections

Application tests

81. The mechanical distributor was used to place the prewetting water, fiberglass scrim reinforcing, and material B on only one and

one-half test sections before material B caused binding of the pump, which, in turn, resulted in failure of the drive transmission. The material was transferred into the pneumatic distributor, which was used to complete placement on the half section and all the remaining sections designated for placement of material B.

82. All materials were placed in hot weather during which frequent rains occurred that kept the clay soil wet or moist.

83. Prechopped fiberglass. All prechopped fiberglass used to reinforce material B was placed by the mulcher, with the same results as discussed in paragraph 53.

84. Fiberglass scrim. The application problems discussed in paragraph 54 for fiberglass scrim placement at Eglin also occurred at Ft. Benning.

85. Material B. Both distributors were used to place material B because the gear pump of the mechanical distributor failed after pumping approximately 800 gal of the material. Application rates were generally slightly lower than the desired rates, and coverage was uniform except for minor fisheyes. The material cured in 4 hr and the tackiness problem encountered at Eglin AFB was not observed.

Operational performance tests

86. These tests were conducted 4 hr after the materials had been placed. A brief summary of each type of test is presented below.

87. Helicopter downwash. Tests were conducted as on material A. Only the scrim-reinforced sections were damaged. The unanchored edges lifted up as the blast passed over them. This lifting was caused by the arrangement of the spray nozzles (see paragraph 78). The edges were pulled back into place and anchors were placed on 3-ft centers along the failed edge, and the failed section was retested. No failures occurred during the retest.

88. Aircraft blast. The C-130 airblast simulator tests were conducted as at Eglin. No failures were observed.

89. Vehicular traffic. There were no failures of the material itself, but the unreinforced 7-lb/sq-yd treatment lost its bond to the soil surface.

PART VI: RETESTS AFTER 90 DAYS

90. Ninety days after the completion of the initial tests at Eglin AFB and Ft. Benning, retests were conducted to determine the condition of the emplaced materials. Results of the retests are presented below.

Retests at Eglin

91. Retest results indicated that materials A and B had increased in strength during the 90-day period between tests. Blasts from the C-130 and helicopter air-impingment simulators produced no failures. The materials supported wheeled traffic with fewer failures than occurred during the initial tests. However, in places, vegetation had grown and lifted up the fiberglass-scrim reinforcement sections from materials A and B (photo 8).

Retests at Ft. Benning

92. In the retests at Ft. Benning, materials A and B withstood the blast from the C-130 simulator with no failures. However, blast from the helicopter blast simulator failed three test sections (A-52, B-50, and B-52) by lifting the unanchored edges as the simulator approached the sections.

93. During the 90 days between tests, all materials had apparently allowed water to penetrate the underlying soil. The wet soil was so weak under eight of the test sections that vehicular traffic caused ruts up to 3 in. in depth and failed the treated surfaces.

PART VII: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Emplacement equipment

94. Generally, the emplacement equipment performed satisfactorily. Specific conclusions are as follows:

- a. The mechanical and pneumatic distributors satisfactorily loaded and emplaced material A, but problems were encountered with material A getting into and curing in the internal bearings of the Viking pump and corroding the cast iron and steel.
- b. The pneumatic distributor satisfactorily emplaced material B; however, the loading pump required constant cleaning and lubricating.
- c. Application rates for both materials were within an acceptable range throughout the tests.
- d. Valves and nozzles performed satisfactorily during application of both materials A and B.
- e. Water was the best of the cleaning agents tried for material A, and JP-4 fuel followed by water was best for material B.
- f. Neither the mulcher nor the experimental dispenser satisfactorily emplaced prechopped fiberglass.
- g. Both scrim attachments satisfactorily emplaced fiberglass scrim.
- h. Adequate data were obtained from the field tests to continue the design of the prototype distributor.

Dust-control materials

95. Material A. Specific conclusions regarding material A are as follows:

- a. Material A remained stable during storage prior to emplacement.
- b. The high viscosity of the material slowed the priming of the pump at times, but once the material was diluted at a ratio of two parts concentrate to one part water, no problems except that discussed in paragraph 94a were encountered.
- c. A good spray pattern and good coverage with only minor fisheyeing combined to give a tough durable film.

d. On fine-grained soils, there was considerable runoff of diluted material A when placed at application rates of 5 lb per sq yd or greater.

e. Material A ponded in depressions when the application rate was 5 lb per sq yd or greater.

f. Material A without reinforcing cannot withstand concentrated traffic.

g. All edges that may be exposed to blast must be anchored by burying.

h. Material A was easy to clean from the distributor using only water.

i. Material A bonded well to landing mat.

96. Material B. Specific conclusions regarding material B are as follows:

a. Material B was unstable during storage in the drums. Fifteen drums of material were unusable when opened at Ft. Benning.

b. Material B pumped easily but froze or bound the pump after only a minimum of pumping.

c. Use of material B in the spray pattern employed in this study resulted in a tough, durable film over both sand and clay, even though fisheyeing occurred. The fisheyes were larger and more numerous on the sand. Additional prewetting water diminished the fisheyeing problem on sand.

d. Material B did not run off at high rates of application.

e. Material B without reinforcing cannot withstand concentrated traffic.

f. All edges that may be exposed to blast must be anchored by burying.

g. JP-4 or a similar solvent is required for cleaning the distributor of material B.

h. Material B bonded well to landing mat.

97. Prechopped fiberglass strands. Specific conclusions regarding prechopped fiberglass strands are as follows:

a. Uniform coverage could not be obtained with available placing equipment.

b. The fiberglass strands conformed to irregularities of the soil surface.

98. Fiberglass scrim. Specific conclusions regarding fiberglass scrim are as follows:

- a. Uniform coverage was easily obtained.
- b. The scrim did not conform to irregularities of the soil surface.
- c. In time, vegetation pushed the fiberglass scrim up out of the film, resulting in a loss of reinforcement.

99. Disk-type anchor. Anchor tacks are expensive and placement is time-consuming. Also, anchors are effective only in anchoring reinforced films.

Recommendations

Emplacement equipment

100. Specific recommendations regarding emplacement equipment are as follows:

- a. In-house investigations should be continued to improve the distributor pump.
- b. Equipment to emplace prechopped fiberglass strands should be developed.

Dust-control materials

101. Specific recommendations regarding dust-control materials are as follows:

- a. Action to correct the deficiencies in materials A and B should be initiated.
- b. Fiberglass scrim should be used as reinforcing material until equipment capable of placing prechopped fiberglass at the required rates in the required quantities can be devised and developed.

Field practice

102. Specific recommendations regarding field practice are as follows:

- a. All edges of film-forming dust-control materials that may be exposed to blast should be anchored by burying.
- b. Film-forming dust-control material that is to be subjected to traffic should be reinforced.

Table 1

Summary of Application and Testing

Test Location	Test Item Code*	Application Rate, lb/sq yd: Emulsion Desired	Emulsion Actual	Fiber-glass**	Total System Desired	Total System Actual	Added Water gal/sq yd	Soil Surface Water Content Percent	Treatment Failure, Percent†: Blast Simulator	Down-wash Simulator	Traffic
Eglin AFB, Fla.	A-30	3.00	2.69	--	3.00	2.69	0.05	6.5	0	0	a
	A-31	2.75	3.00	0.25	3.00	3.25	0.06	6.6	0	0	a
	A-32	2.91	3.14	0.10	3.01	3.24	0.06	7.0	0	0	a
	A-50	5.00	5.75	--	5.00	5.75	0.11	8.5	0	0	a
	A-51	4.75	4.94	0.25	6.00	6.19	0.13	8.9	0	0	a
	A-52	4.91	5.65	0.10	5.01	5.75	0.08	6.6	0	0	a
	A-70	7.00	5.90	---	7.00	5.90	0.03	5.9	--	--	100
	A-71	6.75	5.90	0.25	7.00	6.15	0.03	5.7	--	--	50
	A-72	6.91	5.90	0.10	7.01	6.10	0.03	4.8	--	--	50
	B-30	3.00	4.18	--	3.00	4.18	0.05	6.7	0	60	a
	B-31	2.75	3.34	0.25	3.00	3.59	0.07	8.2	0	0	a
	B-32	2.91	3.41	0.10	3.01	3.51	0.06	7.0	0	0	a
	B-50	5.00	5.65	--	5.00	5.60	1.20	6.3	0	0	a
	B-51	4.75	5.55	0.25	5.00	5.80	1.30	4.9	0	0	a
	B-52	4.91	4.84	0.10	5.01	4.94	0.09	5.9	0	0	a
	B-70	7.00	7.38	--	7.00	7.38	1.10	7.1	--	--	100
	B-71	6.75	7.38	0.25	7.00	7.63	1.10	5.4	--	--	60
	B-72	6.91	6.69	0.10	7.01	6.79	1.10	5.9	--	--	50
Ft. Benning, Ga.	A-30	3.00	2.48	--	3.00	2.48	0.04	4.2	0	0	0
	A-31	2.75	2.66	0.25	3.00	2.91	0.23	10.6	0	0	0
	A-32	2.91	2.45	0.10	3.01	2.55	0.04	11.3	0	0	0
	A-50	5.00	3.68	--	5.00	3.68	0.06	7.3	0	0	0
	A-51	4.75	4.89	0.25	5.00	5.14	--	5.6	0	0	0
	A-52	4.91	4.78	0.10	5.01	4.88	0.07	10.1	0	8	0
	A-70	7.00	6.53	--	7.00	6.53	0.08	13.1	--	--	0
	A-71	6.75	6.53	0.25	7.00	6.78	0.08	14.1	--	--	0
	A-72	6.91	6.53	0.10	7.01	6.63	0.08	10.2	--	--	0
	B-30	3.00	2.85	--	3.00	2.85	0.08	8.2	0	0	0
	B-31	2.75	3.52	0.25	3.00	3.77	0.04	9.8	0	0	0
	B-32	2.91	3.34	0.10	3.01	3.44	0.17	6.3	0	b	0
	B-50	5.00	4.12	--	5.00	4.12	0.05	11.2	0	0	0
	B-51	4.75	4.54	0.25	5.00	4.79	0.05	7.3	0	0	0
	B-52	4.91	4.05	0.10	5.01	4.15	0.05	12.1	0	b	0
	B-70	7.00	6.59	--	7.00	6.59	0.05	6.2	--	--	25
	B-71	6.75	6.59	0.25	7.00	6.84	0.05	5.7	--	--	0
	B-72	6.91	6.76	0.10	7.01	6.86	0.05	4.1	--	--	0

* Test item code: A,B — Material identification, i.e. A = polyvinyl acetate water emulsion, and B = cationic asphalt-neoprene emulsion.
3,5,7 — Total intended weight per square yard of treatment (emulsion plus reinforcing), lb.
0,1,2 — Reinforcing, i.e., 0 = none used, 1 = one chopped fiberglass, 2 = fiberglass scrim.

** Prechopped fiberglass strands and fiberglass scrim were tested. Rates of application for these two were 0.25 and 0.10 lb/sq yd, respectively. Overlap was not included in fiberglass scrim.

† a indicates failure occurred where traffic crossed ruts made by distributor.
b indicates an item where unanchored edge failed, disk-type anchor was placed, and item was retested without failure.

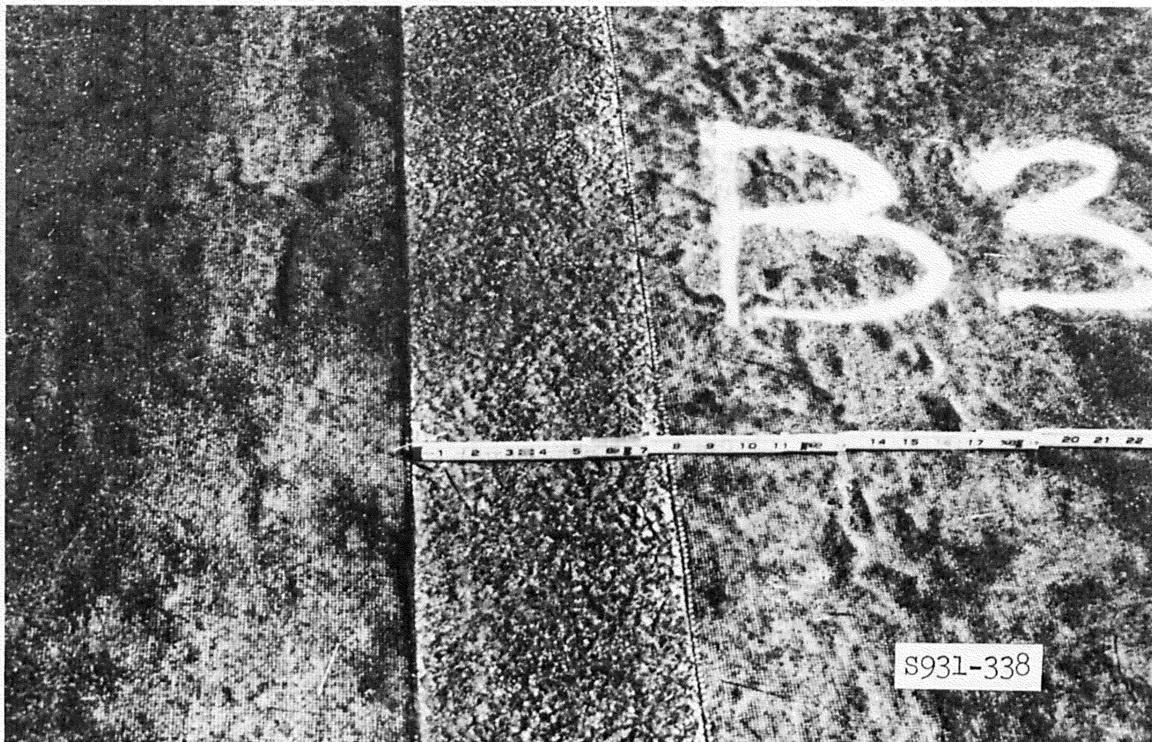


Photo 1. Area where scrim did not overlap, leaving 8-in. nonreinforced strip

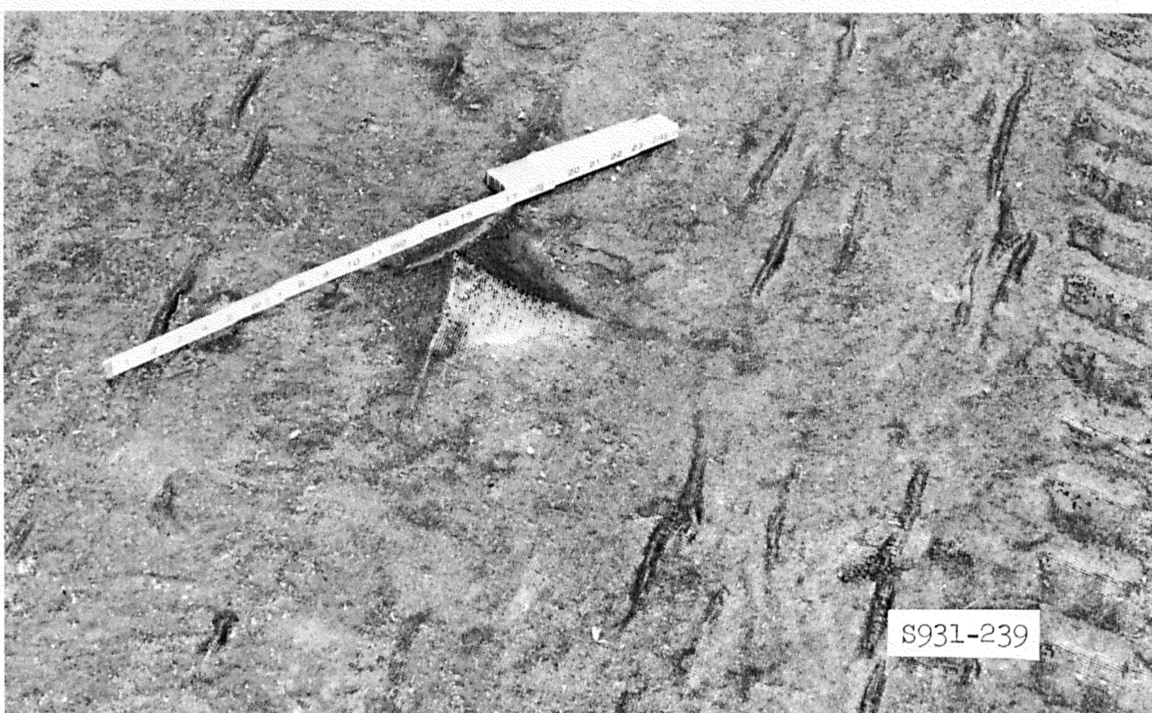


Photo 2. Tentlike area where fiberglass scrim was placed over roots or debris

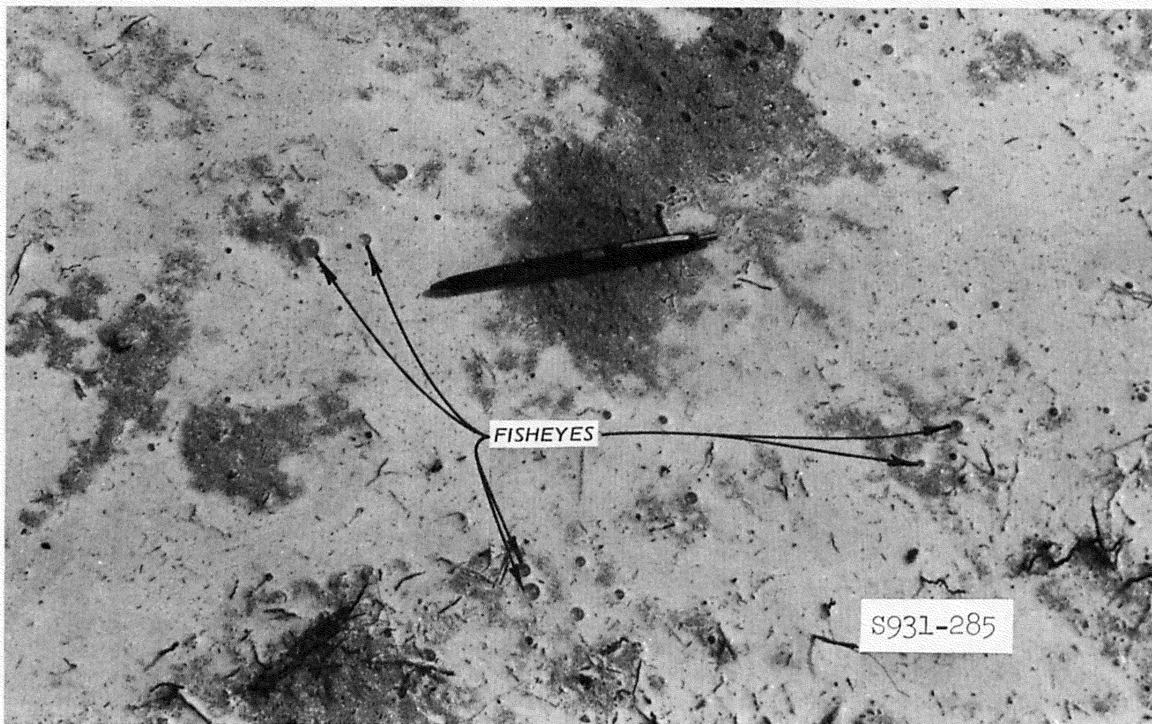


Photo 3. Fisheyes in material A

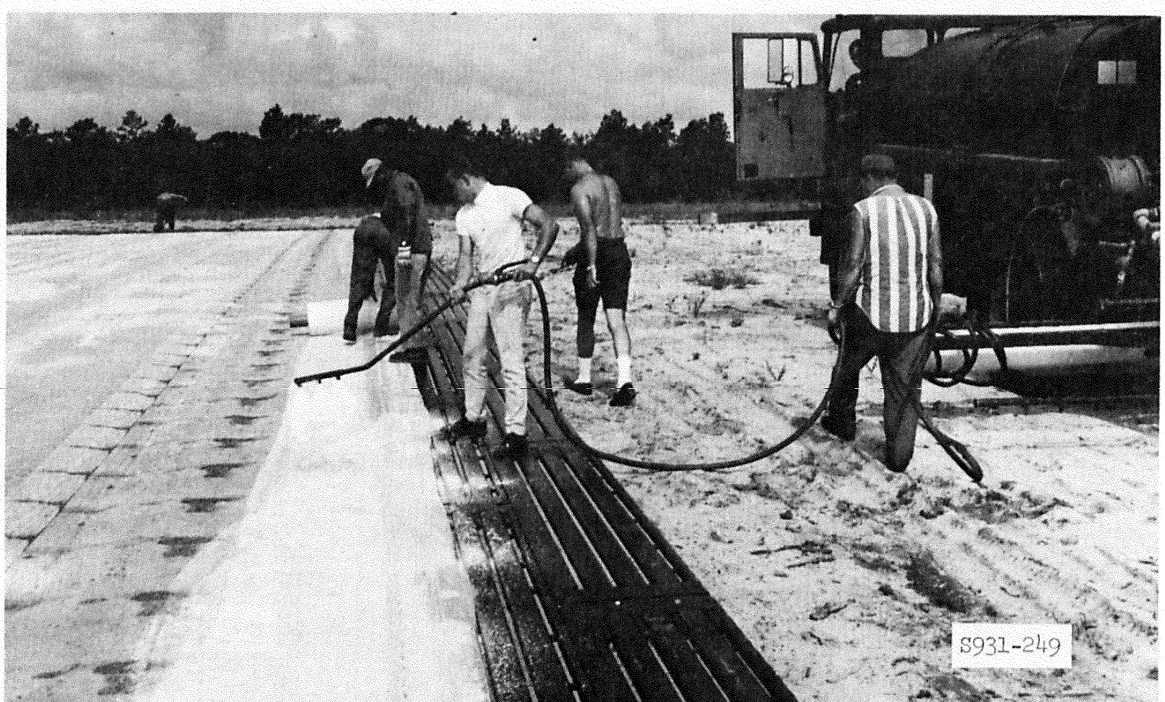


Photo 4. Fiberglass scrim being placed along edge of landing mat and sprayed with hand-held spray bar

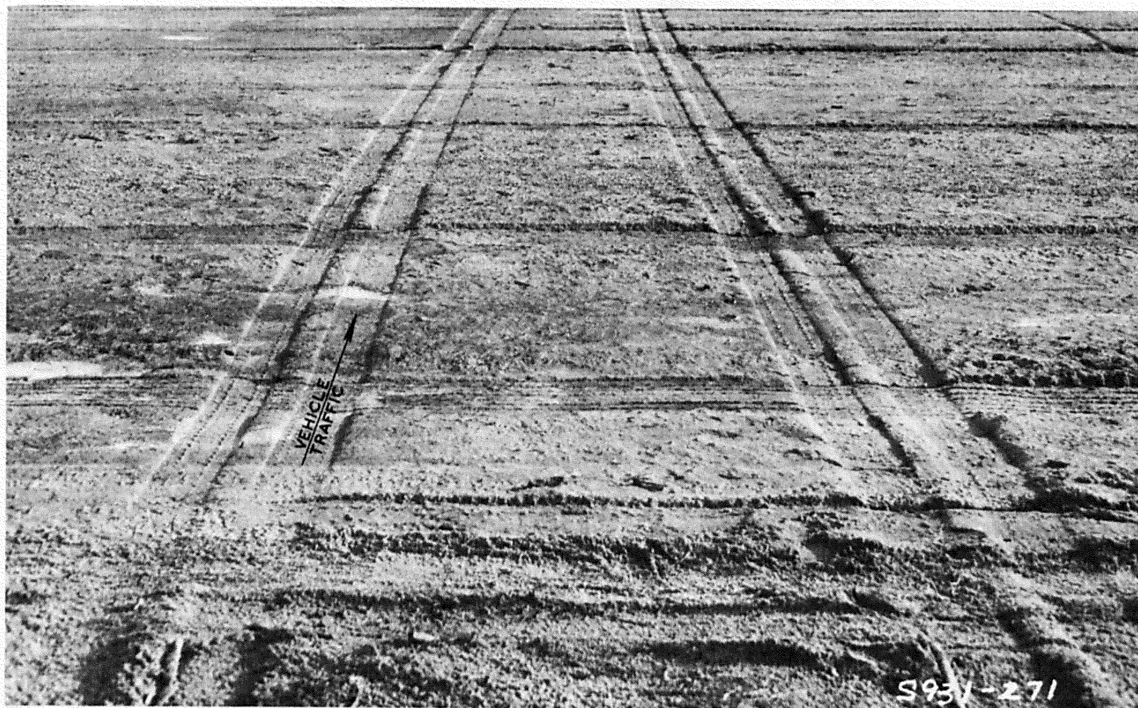


Photo 5. Damage caused by 2-1/2-ton truck traffic across ruts left by distributor traffic

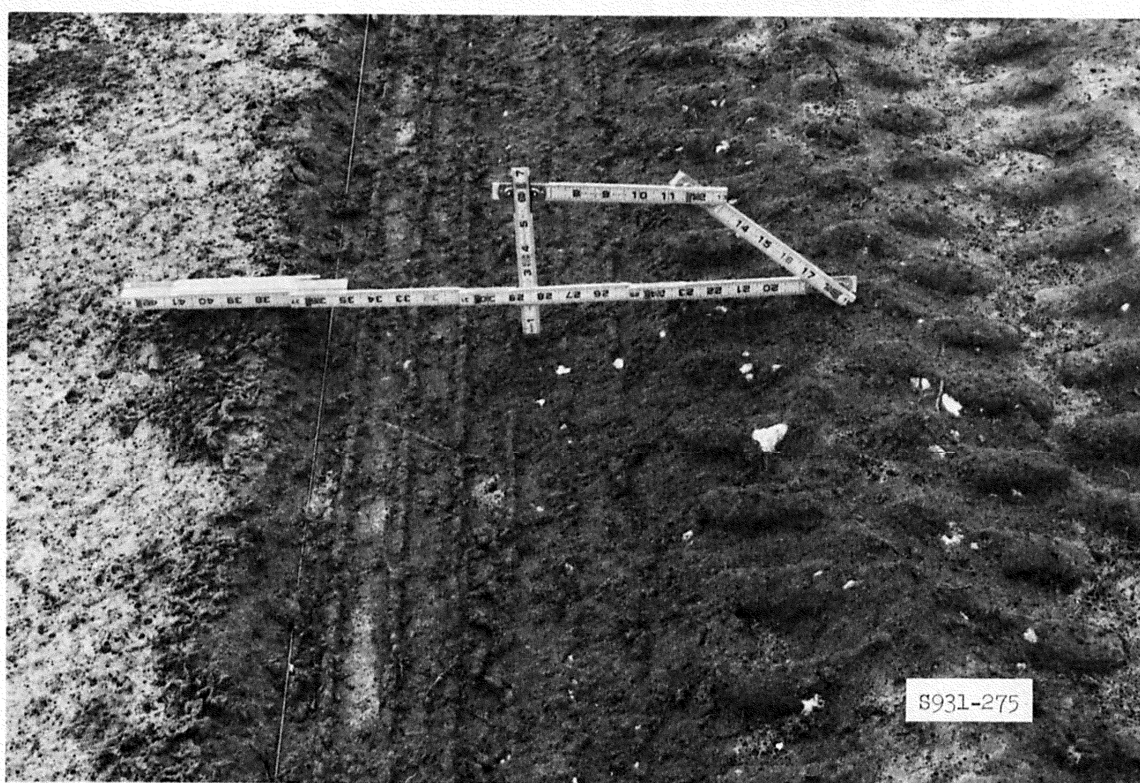


Photo 6. Fisheyes in material B. Note ruts caused by operation of the pneumatic distributor

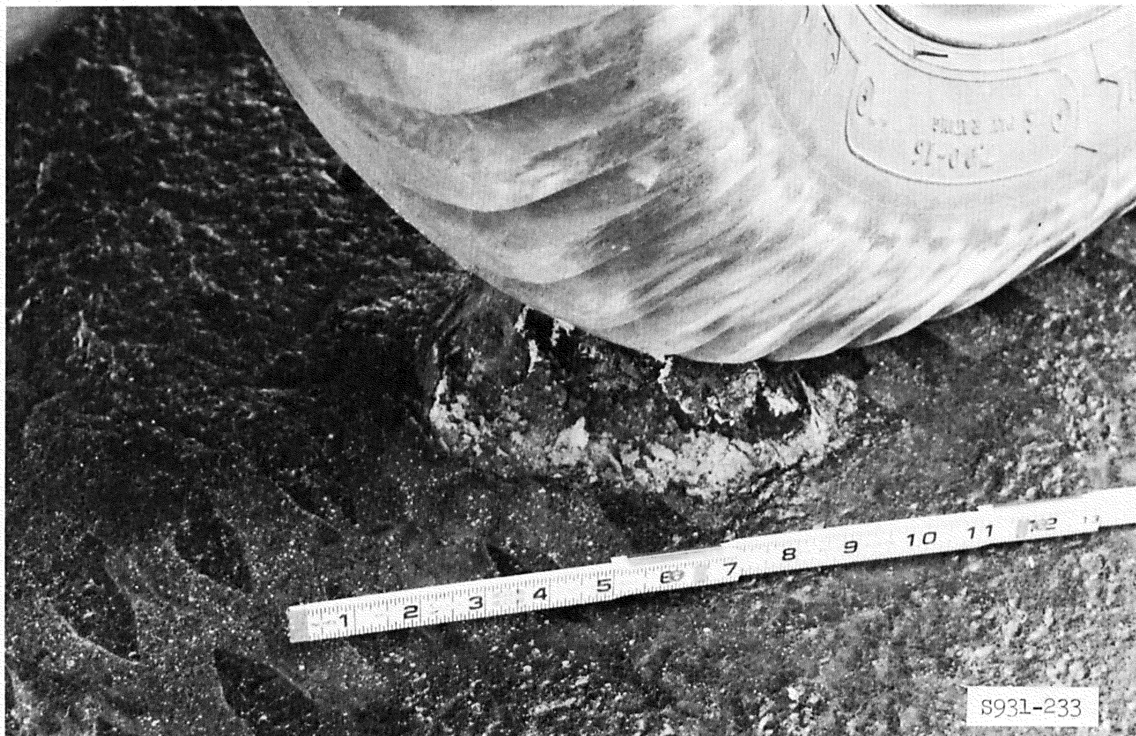


Photo 7. Tacky material B being picked up from surface by tire of test vehicle

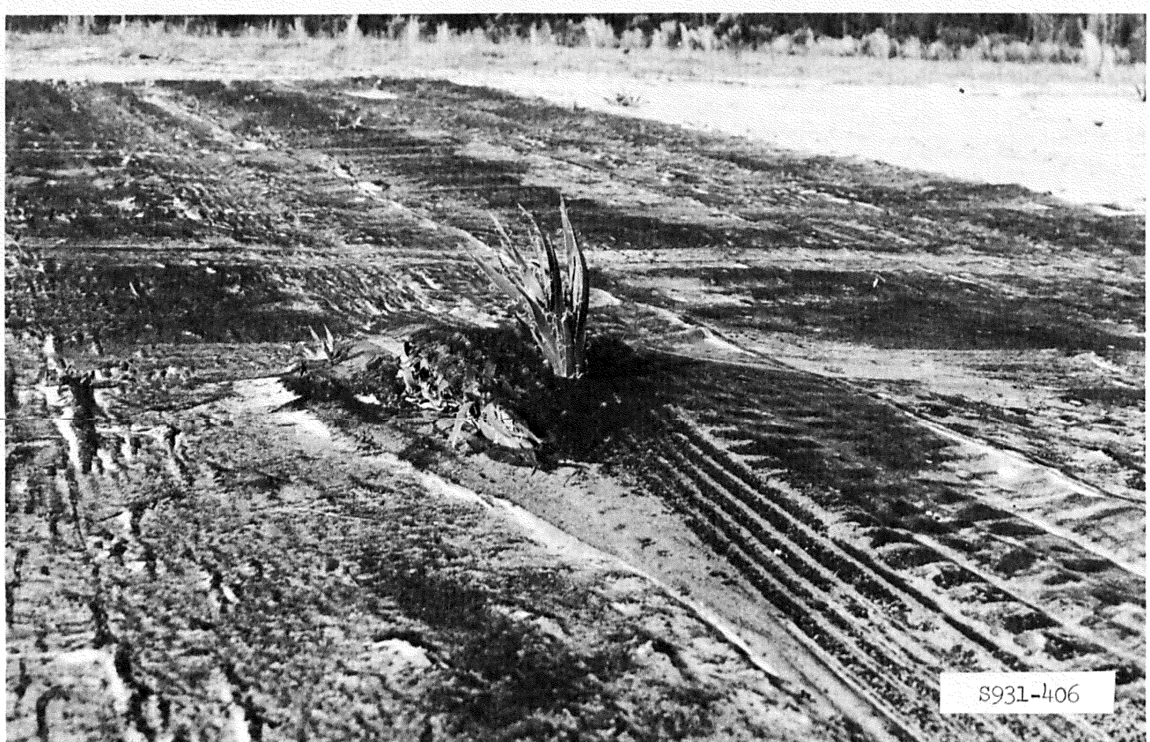
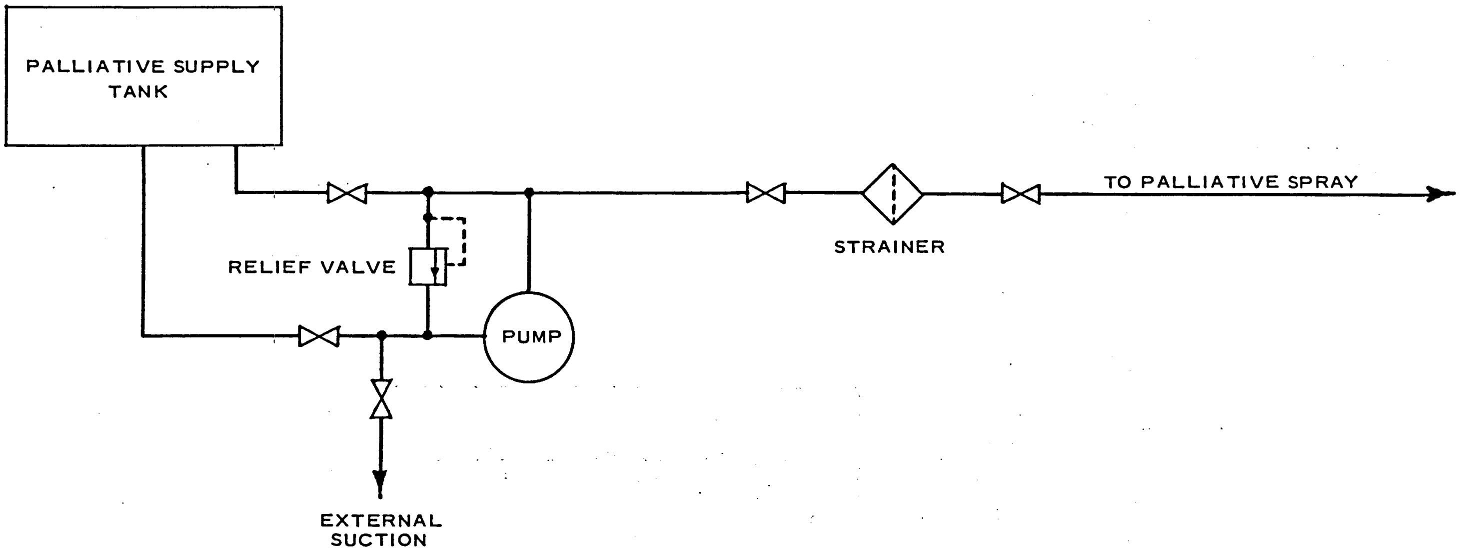
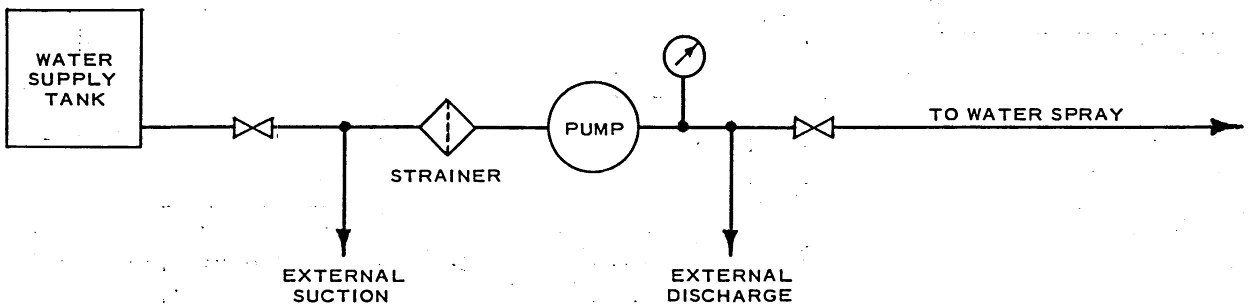


Photo 8. Vegetation pushing up fiberglass scrim at Eglin AFB, Fla., 90 days after application (scrim cut for photo)



a. EMULSION SUPPLY SYSTEM



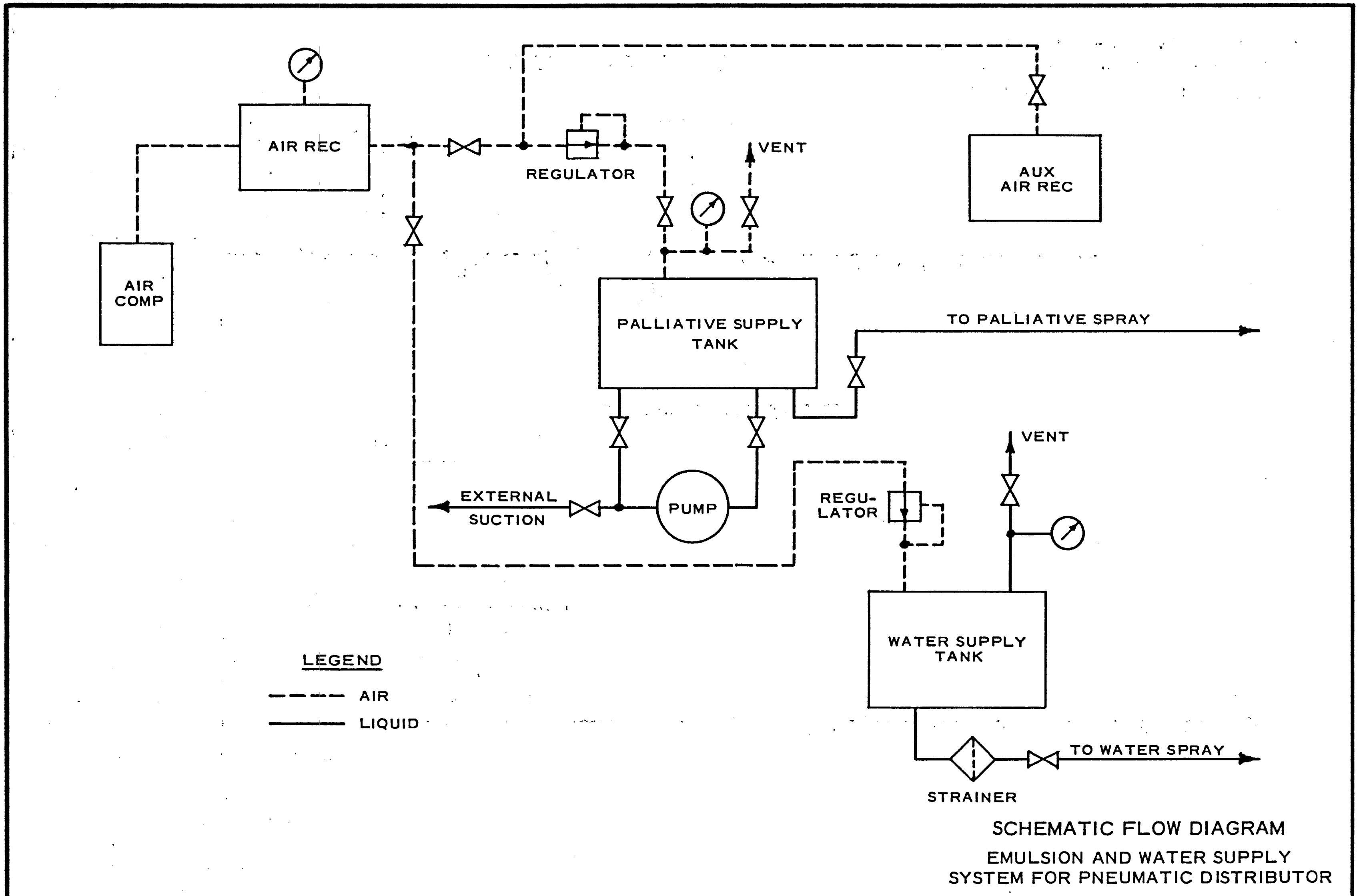
b. WATER SUPPLY SYSTEM

SCHEMATIC FLOW DIAGRAMS

EMULSION AND WATER SUPPLY SYSTEMS FOR MECHANICAL DISTRIBUTOR

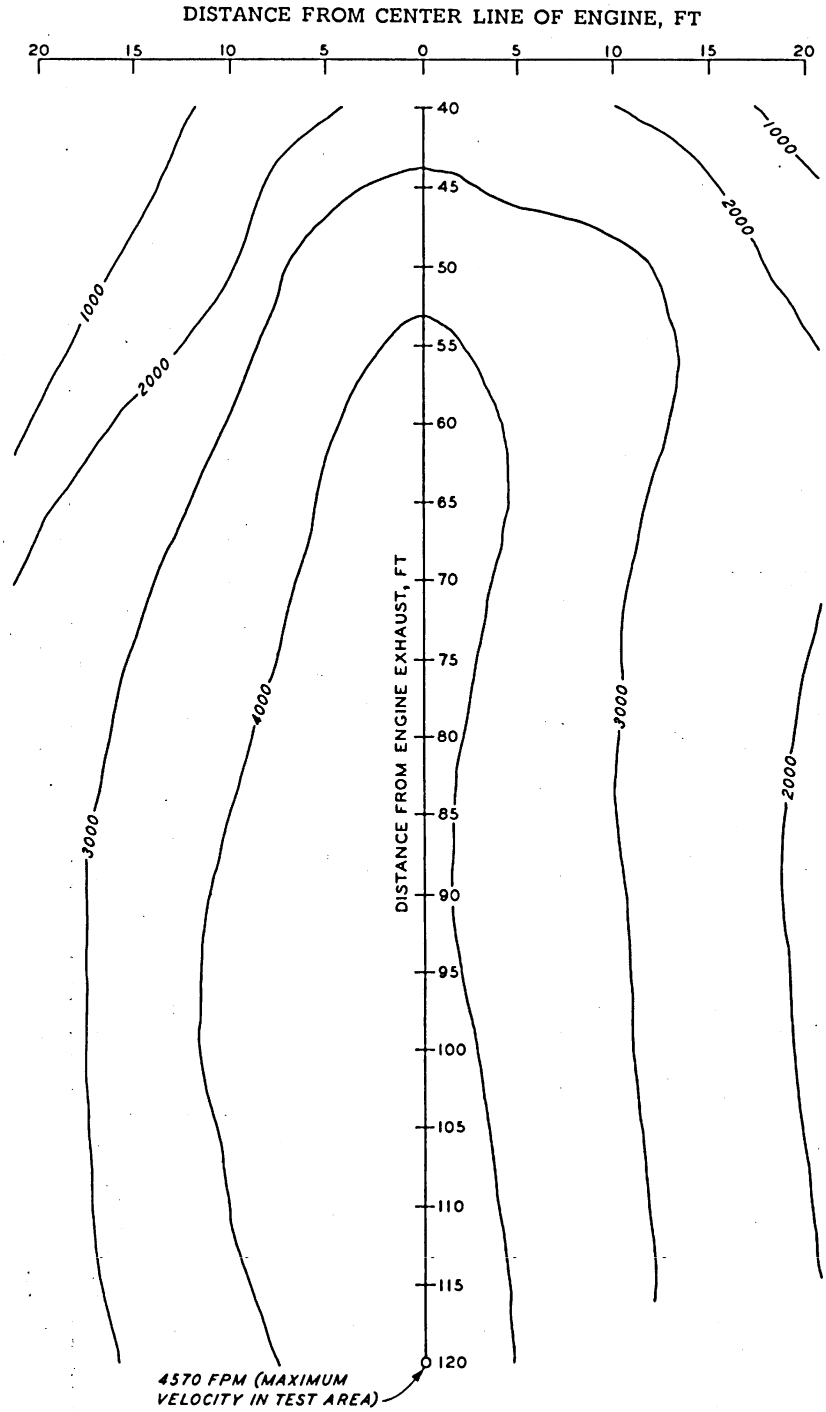
PLATE I

PLATE 2



SCHEMATIC FLOW DIAGRAM

EMULSION AND WATER SUPPLY
SYSTEM FOR PNEUMATIC DISTRIBUTOR

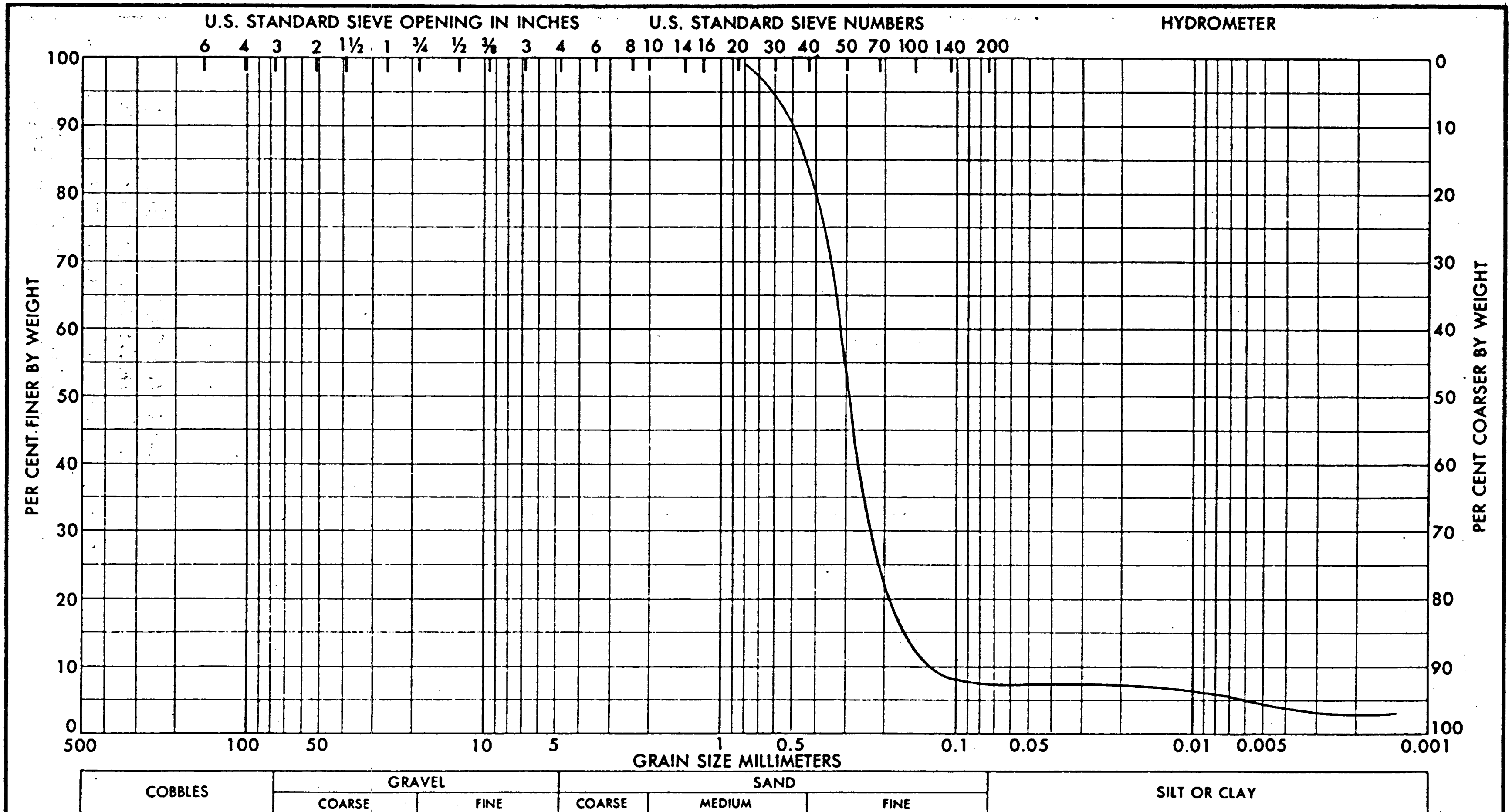


AIR VELOCITY CONTOURS AT GROUND ELEVATION

USING AIRCRAFT BLAST SIMULATOR

MAXIMUM VELOCITY FROM ENGINE TILT OF 2.5 DEGREES

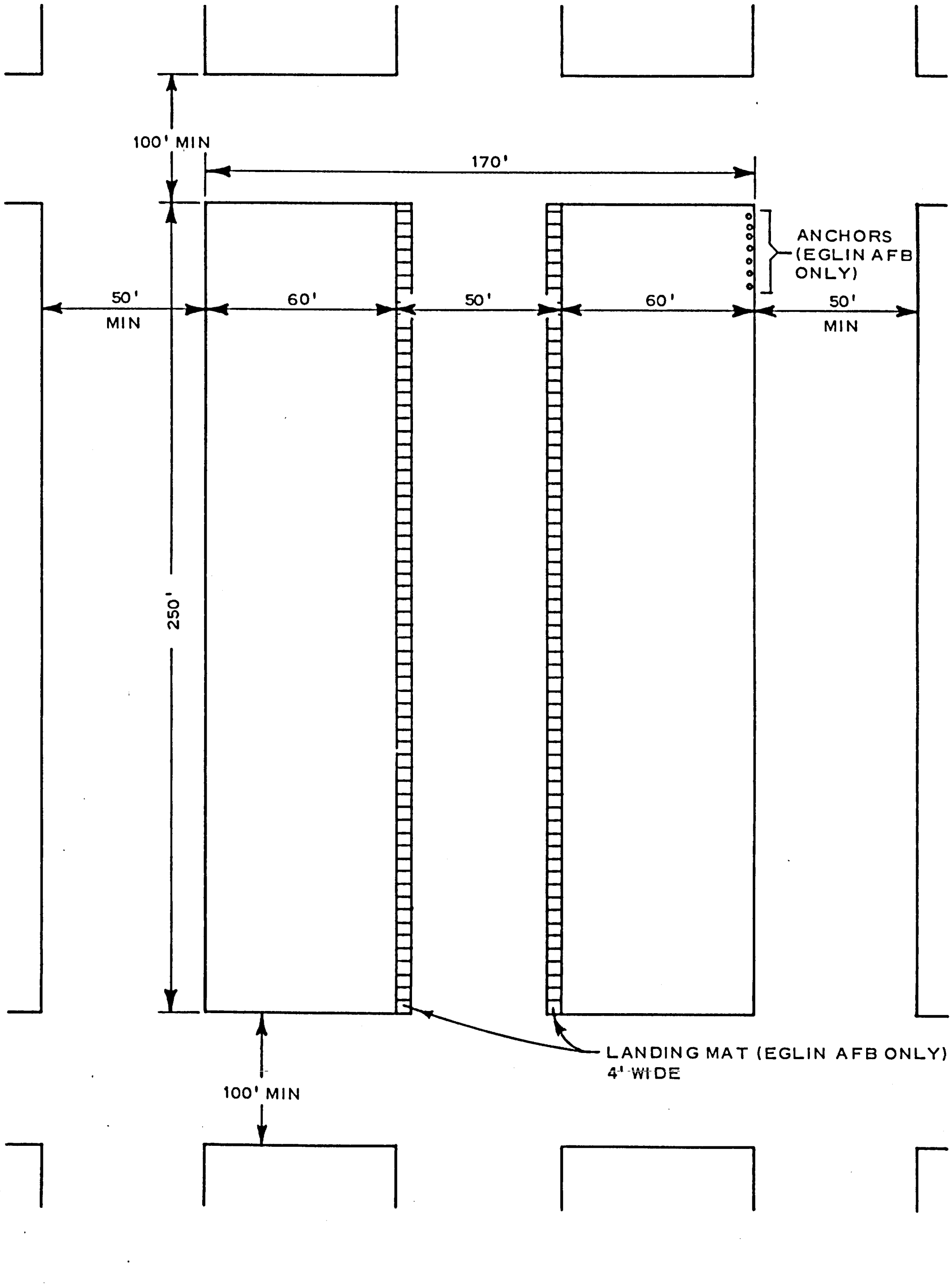
PLATE 4



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
		SAND (SP-SM)		NONPLASTIC		

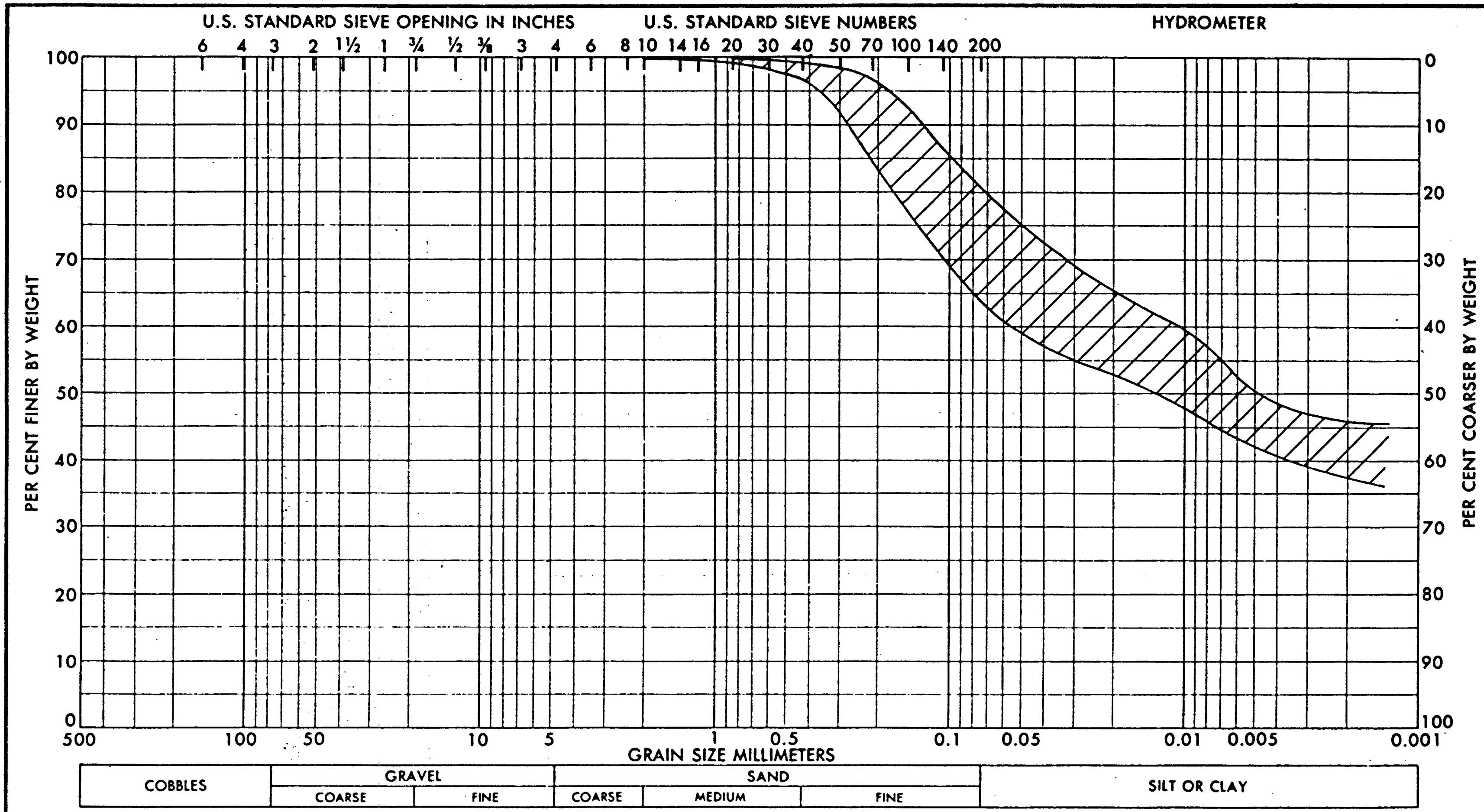
CLASSIFICATION DATA
AND GRADATION

EGLIN AFB TEST AREA



TEST SECTION LAYOUT

PLATE 6



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
RANGE		CLAY (CL-CH)		43-59	19-29	23-34
AVERAGE				52	24	28

CLASSIFICATION DATA
AND GRADATION

FT. BENNING TEST AREA

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

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13. ABSTRACT
This report describes and presents the results of engineer design tests (EDT) of two dust-control materials, a polyvinyl acetate (PVA) water emulsion and a cationic asphalt-neoprene emulsion (CANE), and two distributors, one pneumatic and one mechanical, that were used to apply the PVA and CANE. Both distributors were used to apply the PVA and CANE with no reinforcing, with fiberglass scrim reinforcing, and with prechopped fiberglass reinforcing to sand and clay soils in an intermediate climate. The materials were allowed to cure for 4 hr after placement and were then subjected to the simulated airblast of a CH-47 helicopter and a C-130 aircraft and to traffic by 1/4- and 2-1/2-ton vehicles. Only minor deficiencies in the PVA and CANE, i.e., instability in storage, excessive runoff, and tackiness after 4 hr curing time, were observed during testing. The pneumatic distributor sprayed both materials with ease, but the mechanical distributor encountered difficulty in spraying the CANE. Based on the results of the investigation reported herein, the following recommendations are considered warranted: (a) Action should be initiated to correct the deficiencies in PVA and CANE. (b) Fiberglass scrim should be used as reinforcing material until equipment capable of placing prechopped fiberglass at the required rates and in the required quantities can be devised and developed. (c) Investigations for improving the distributor pump should be continued. (d) All edges of film-forming dust-control materials that may be exposed to blast should be anchored by burying. (e) Film-forming dust-control materials that are to be subjected to traffic should be reinforced.

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Cationic asphalt-neoprene emulsion						
Dust control						
Polyvinyl acetate						