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CLAY CAP TEST PROGRAM FOR THE MIXED WASTE MANAGEMENT FACILITY CLOSURE AT THE SAVANNAH RIVER SITE (U)

by

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ABSTRACT

A 58 acre low-level radioactive waste disposal facility at the Savannah River Site, a Department of Energy facility near Aiken, South Carolina, requires closure with a RCRA clay cap. A three-foot thick cap requiring 300,000 cubic yards of local Tertiary Kaolin clay with an in-situ permeability of less than or equal to 1 x 10^{-7} centimeters per second is to be constructed.

The Clay Cap Test Program was conducted to evaluate the source, lab permeability, in-situ permeability, compaction characteristics, representative kaolin clays from the Aiken, SC vicinity. Nine large scale test caps were constructed of Tertiary and Cretaceous age clays. For each clay cap type a test cap was built at optimum and two percent wet of optimum moisture content. The clay material was sized using either a shredder or a mobile recycler, moisture conditioned using a water truck and the recycler, transported to the test panel with a scraper, graded with a motor grader, and compacted with a tamping-foot compactor.

All of the Tertiary kaolin clays installed at 2% wet of optimum and compacted between 29 and 31 percent are capable of in-situ permeabilities of less than 1 x 10^{-7} cm/sec. The ratio of field to laboratory permeability for these compacted clays ranges from 1.1 to 3.4. The Cretaceous Kaolin clay, a sandier and less plastic clay, was not capable of an in-situ permeability of less than 1 x 10^{-7} cm/sec.

1.0 INTRODUCTION

The Mixed Waste Management Facility (MWMF) is a 58 acre mixed waste site at the Savannah River Site (SRS), a Department of Energy Facility near Aiken, South Carolina. This site was operated as a radioactive waste disposal facility until 1986 when hazardous waste was identified in the facility. The site is within an on-going radioactive waste disposal facility. The Resource Conservation and Recovery Act-(RCRA) Closure will include waste trench consolidation by dynamic compaction and a low permeability clay cap. This project has an estimated constructed value of $53 million and is the largest mixed waste site closure to date at the Savannah River Site.

The multi-layered closure cap will include over 300,000 cubic yards of clay constructed to a thickness of three feet. The clay must have an in-situ permeability of less than or equal to 1×10^{-7} centimeters per second. The Clay Cap Test Program was conducted to evaluate the source, lab permeability, in-situ permeability, compaction characteristics, constructability, and quality control/quality assurance requirements of the clay.

This program was subcontracted by E. I. du Pont de Nemours and Co., Atomic Energy Division of Charlotte, NC, to Mueser Rutledge Consulting Engineers of New York, NY, and Trautwein Soil Testing Equipment Co. of Houston, TX, under the technical direction of Chas. T. Main, Inc. of Charlotte, NC.

2.0 SOURCE

Eight potential on-site SRS borrow sites were investigated as possible clay sources. Two areas were identified where significant relatively shallow clay deposits are present. The most promising site is about 30 acres where significant clay layers averaging two to ten feet thick are present underlying typically 10 to 20 feet of overburden sandy soils. Forty test pits and 72 borings were made to determine the extent of the clay layers. A combination of the two identified clay sites revealed that sufficient quantities of on-site clays were available for the MWMF closure cap. These clays met laboratory permeability requirements but were not tested for in-situ permeability. However, due to construction and environmental concerns, it was decided by SRS Construction Management not to pursue on-site clay sources.

Six sources of off-site clay sources were investigated. These include: Off-site sources similar to on-site clays, Piedmont South Carolina clays, alluvial clays, coastal clays, soil bentonite, and local kaolin mines. The most economically feasible source proved to be from the kaolin mines located 15 to 25 miles from SRS.

About 90% of the U.S. production of commercial kaolin clay comes from sedimentary deposits along the Fall Line in Georgia and South Carolina. The Fall Line is the boundary between the Piedmont and Coastal Plain

Provinces and is approximately 20 miles north and west of SRS. Along the Fall Line, thick kaolin clay beds from Tertiary and Cretaceous geologic periods (more than 60 million year ago) are found at relatively shallow depths. Commercial grade kaolins have a multitude of uses as an inert filler in the paper and rubber industries and as a catalyst in oil refining. Kaolin is used to reinforce and stiffen rubber products such as insulated wire, floor covering and rubber parts for the automotive industry. It is also used in the manufacture of other products such as bricks, ceramics, insecticides, fiberglass, paints, and adhesives. Large quantities of less than commercial quality clay material is readily available to support large scale SRS closure projects.

3.0 TEST PROGRAM

The intent of the test program was to determine compaction characteristics of four representative kaolin clays (three Tertiary and one Cretaceous age) from the Aiken SC vicinity and to determined if an in-situ permeability of 1 x 10^{-7} cm/sec or less is feasible for these clays. For each clay, there is a stockpile area, a conditioning area, and provisions for two test panels. The intent was to construct test panels for each clay at approximately optimum water content and a few percent wet of optimum water content, thereby determining if a maximum permeability of 1 x 10^{-7} cm/sec could be achieved. A ninth test panel was added which allowed clay to be conditioned directly on the panel and then compacted.

Approximately 2,500 tons (about 100 truckloads) of clay from each of the selected kaolin pits were trucked to the site and stockpiled in designated areas. Natural water content for the Tertiary clays generally ranged from 20 to 25 percent. Natural water contents for the Cretaceous kaolin generally ranged from 25 to 27 percent. To ensure uniform wetting the blocky clays were broken down to a 1-1/2 inch maximum clod size initially using a stationary Gleason shredder and finally using a BROS LSPRM-8A travelling pavement recycler which was found to be more versatile.

Wetting of the clays was accomplished by spreading a six to nine inch thick layer of raw clay in a conditioning area followed by alternating passes of a water truck and travelling recycler. This method resulted in excellent mixing of the clay. After conditioning the clay to its placement water content, the clay was covered with plastic and allowed to cure overnight. The conditioned clay was then transported to test panels using a CAT 623E self loading scraper. Motor Graders were used to spread and scarify the clay.

Test panels were compacted using a CAT 815B tamping foot compacted. The compacted lift thickness was determined by surveying the elevation of the bottom of imprints after compaction of each lift.

Laboratory and field quality control tests were conducted to elevate the pre-infiltration test conditions. Laboratory tests included Laboratory Water Content, Atterberg Limits, Sieve Analysis, Moisture - Density Relation, and One Point Density. Field Test included Microwave Water Content, In-Place Nuclear Density, and In-Place Sand Cone Density. Undisturbed sample borings were taken by hydraulically pressing three-inch diameter tubes into the compacted fill through the bottom three lifts of the test panel fills. These samples were tested for lab permeability to correlate with field infiltrometer tests.

A Trautwein type, Sealed Double Ring Infiltrometer (SDRI) was installed to determine in-situ permeabilities in the center of each test panel. These infiltrometers have an "outer ring" constructed of four 12-foot long panels grouted into the test pad to establish one dimensional flow. The sealed square "inner ring" is constructed with four, five-foot long panels grouted into the test pad. The level of water in the infiltrometer was maintained at approximately 12 inches. The volume of water infiltrating through the inner ring was measured periodically by weighing refillable plastic IV bags to determine the infiltration rate. Tensiometers were installed in each of the panels at depths of 6, 12, and 18 inches below the fill surface to monitor the progress of the wetting front. Test units were filled with water and covered to protect from freezing. Tests were conducted for 98 to 158 days to insure the infiltration rates had stabilized.

Upon stabilization of the infiltrometer rates, a blue methanol dye was injected into the infiltrometers. The purpose of the dye was to identify any imperfections or joint structures within a clay test panel. In all cases, dye penetrated no more than one-sixteenth of an inch below the clay fill surface after leaving in place for up to one month. The test apparatus was removed and additional undisturbed samples were taken. In all test panels the side walls appeared well compacted and free of any vertical cracks.

An additional study was conducted to evaluate a simulated subsidence repair zone for the clay cap. This study was conducted to demonstrate a suitable method of clay replacement and compaction for areas where the clay cap might eventually experience significant subsidence. Another study simulated the effects of gravel impregnation into the clay due to the load of heavy placement equipment.

4.0 SUMMARY

Field test results indicated that all the tested Tertiary kaolins are capable of in-situ permeabilities of less than 1×10^{-7} cm/sec when compacted between 29 and 31 percent; 2 and 4 percent wet of optimum. The average standard Proctor compaction on these panels was between 94 and 100 percent. The Cretaceous kaolin, a significantly sandier and less plastic clay, was not capable of an in-situ permeability of 1×10^{-7} cm/sec.

There is good agreement between infiltrometer results and laboratory permeability tests on undisturbed samples recovered from the test panels compacted between 2 and 4 percent wet of optimum. The ratio of field to laboratory permeability for these compacted clays ranges from 1.1 to 3.4.

The close agreement between laboratory and field permeabilities is consistent with the manner in which the tests pads were constructed. Compacted earthen liners or covers tend to have far less preferential pathways for moisture flow if 1) clods are broken down; 2) moisture content is uniform and carefully controlled; 3) the compaction moisture is near the plastic limit; and 4) soil clods mesh during compaction.

5.0 CONSTRUCTION STATUS

Overall closure construction is approximately 30 percent complete at this writing. Pre-densification of the waste trenches by dynamic compaction methods is approximately 70 percent complete. Three Lampson "Thumper" cranes are dropping 20 ton weights from 42 feet high to compress trench waste six feet below present grade. Clay placement started in late August, 1989 by specified methods. Clay is placed in one acre patchwork-type patterns. Clay placement and Closure completion is projected by December, 1990.

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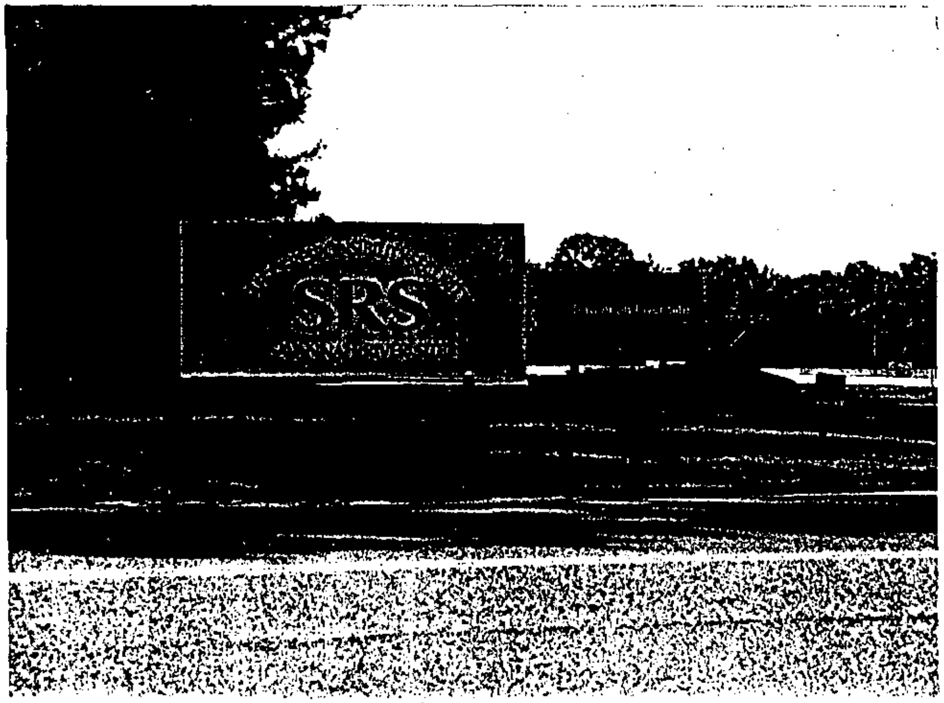
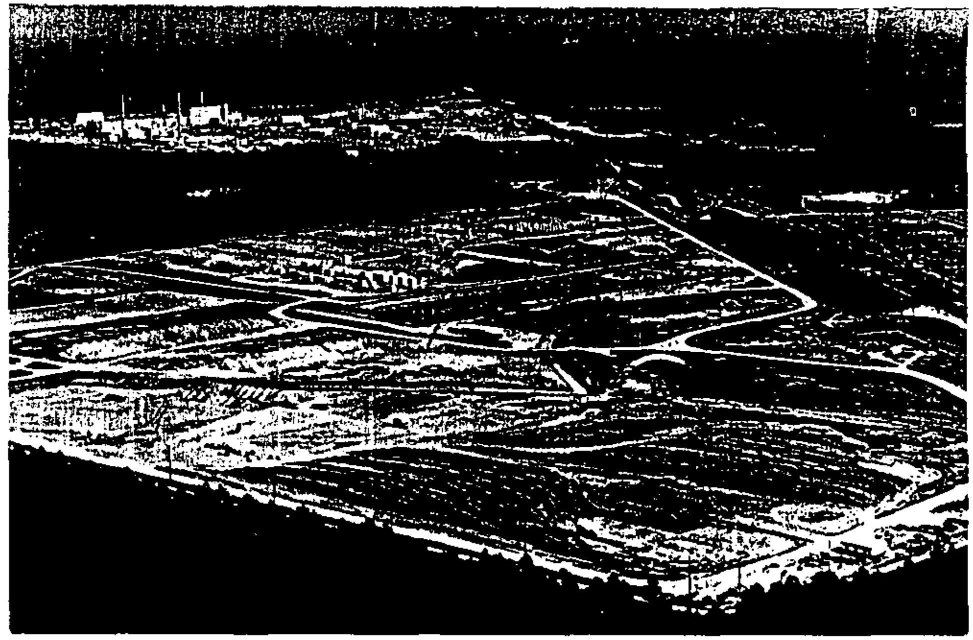
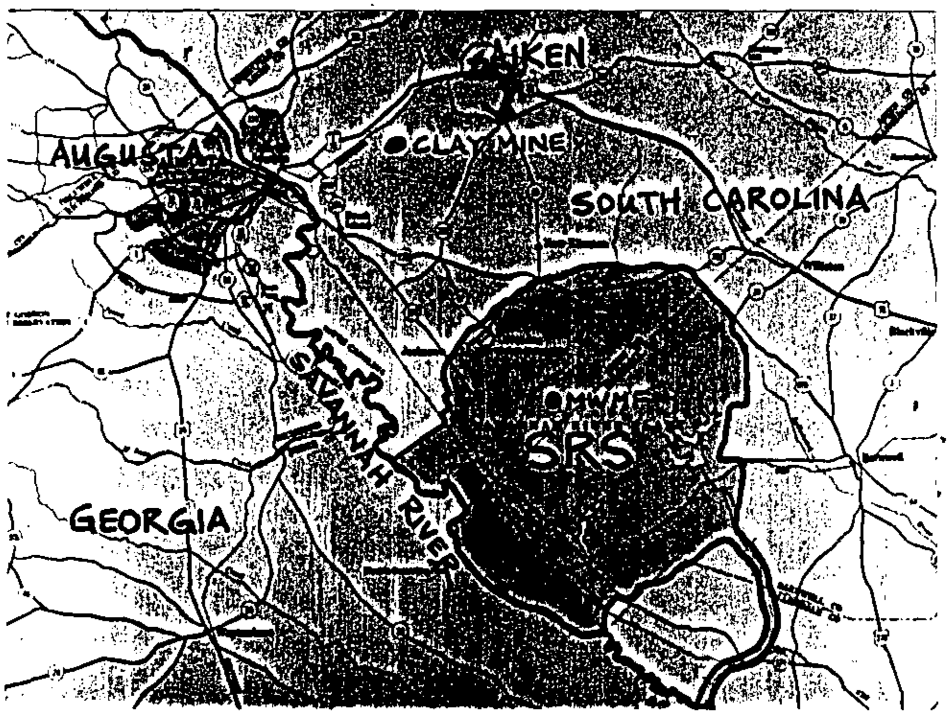
Jeffrey W. newell is a Principal Geologist and Geotechnical Group Supervisor in the Nuclear Environmental Department of Chas. T. Main, Inc. in Charlotte, North Carolina. Mr. Newell holds a B.S. in Earth Science and Geography from the University of North Carolina at Charlotte. He is responsible for group management, geologic studies, geotechnical evaluations, and hydrogeologic investigation related to the design of multiple radioactive, hazardous and mixed waste projects at the Savannah River Site.



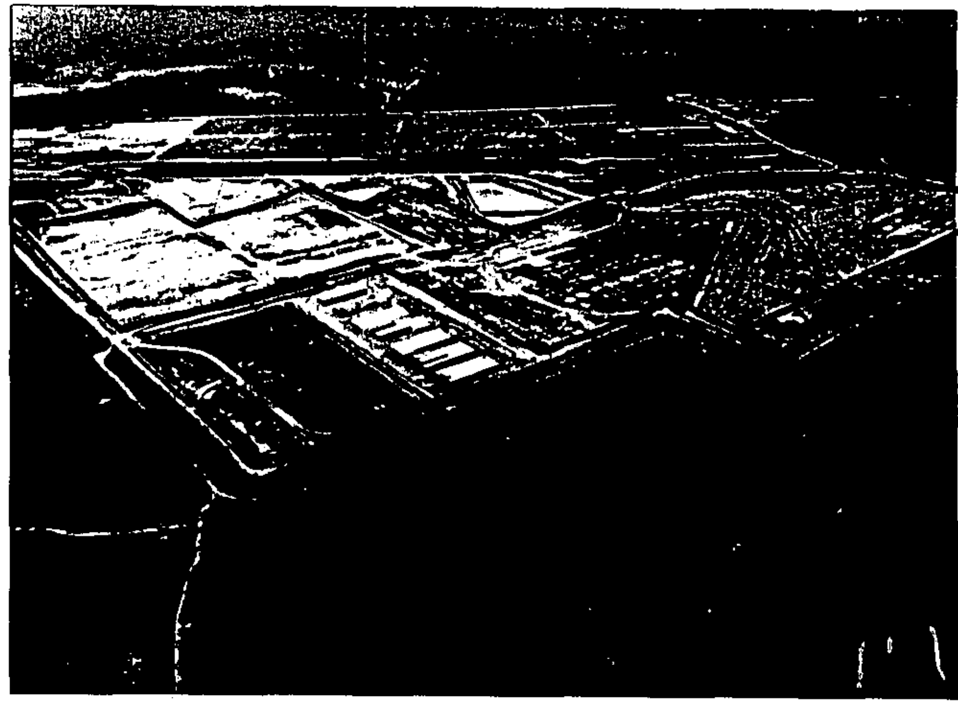
SAVANNAH RIVER SITE



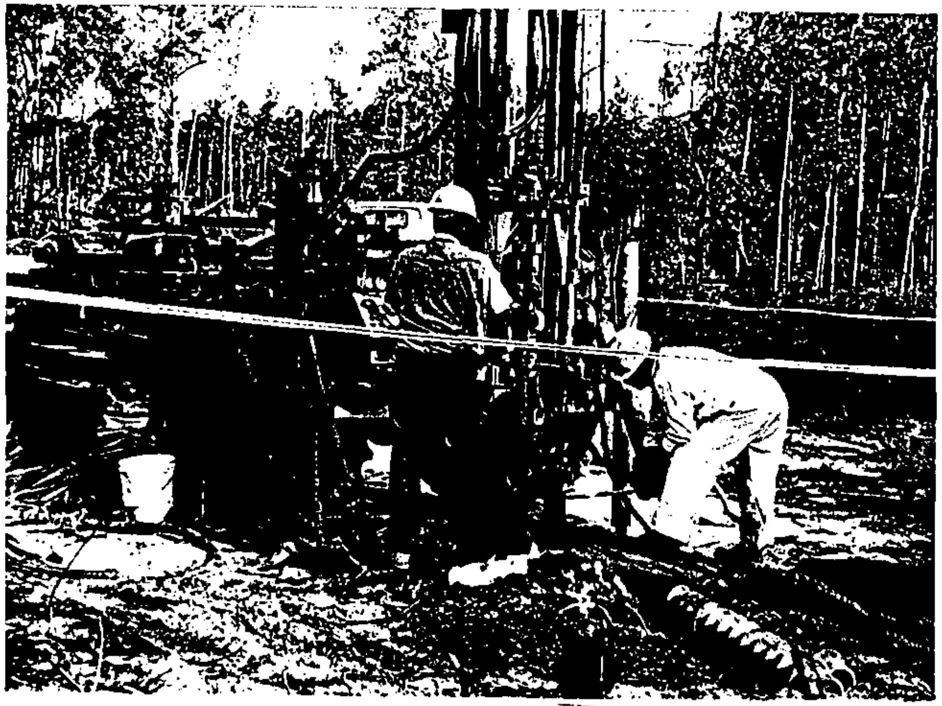
MIXED WASTE MANAGEMENT FACILITY (MWMF)



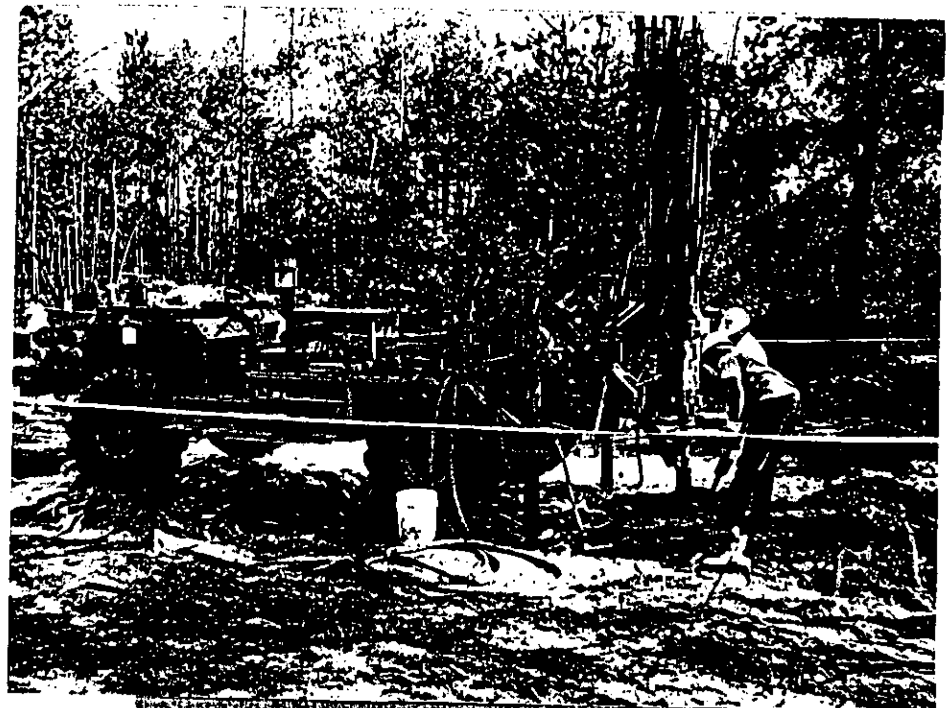
SRS NEAR AUGUSTA, GA & AIKEN, SC



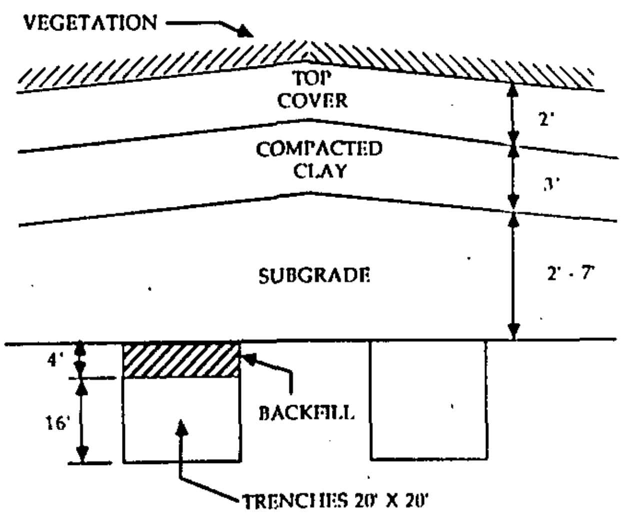
MWMF CLOSURE PROJECT (58 ACRES)



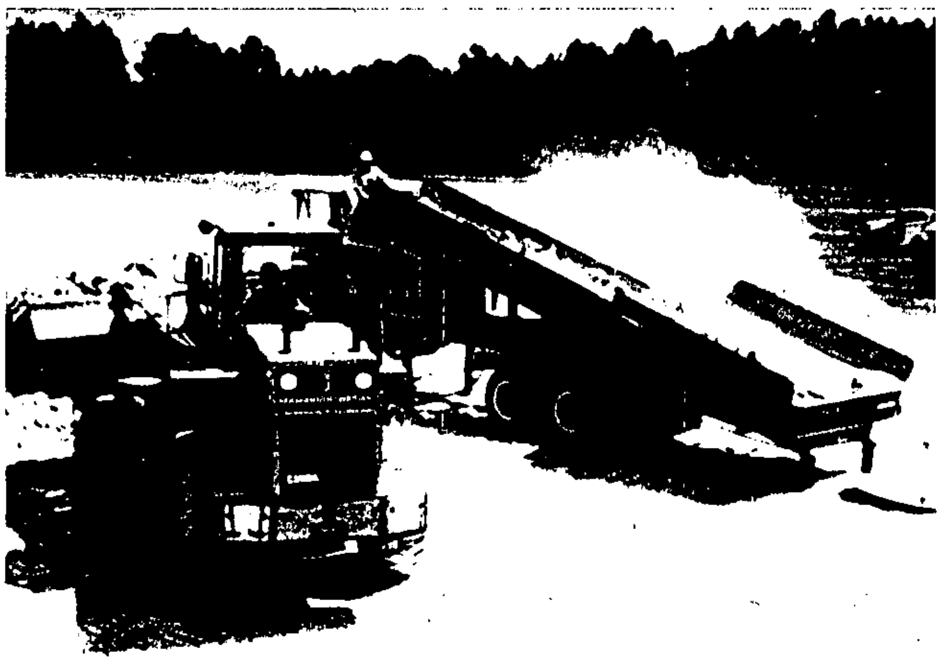
ON-SITE CLAY SEARCH



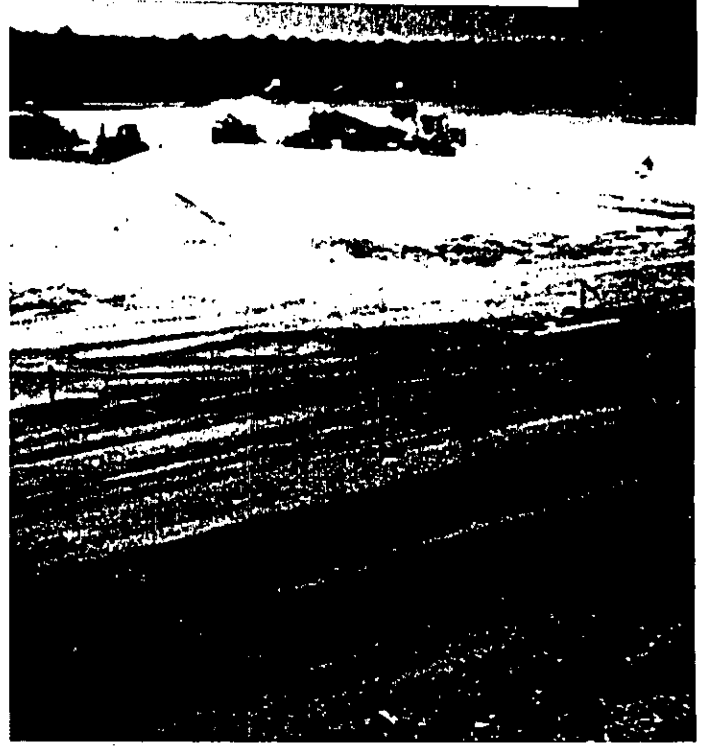
CAP CROSS SECTION

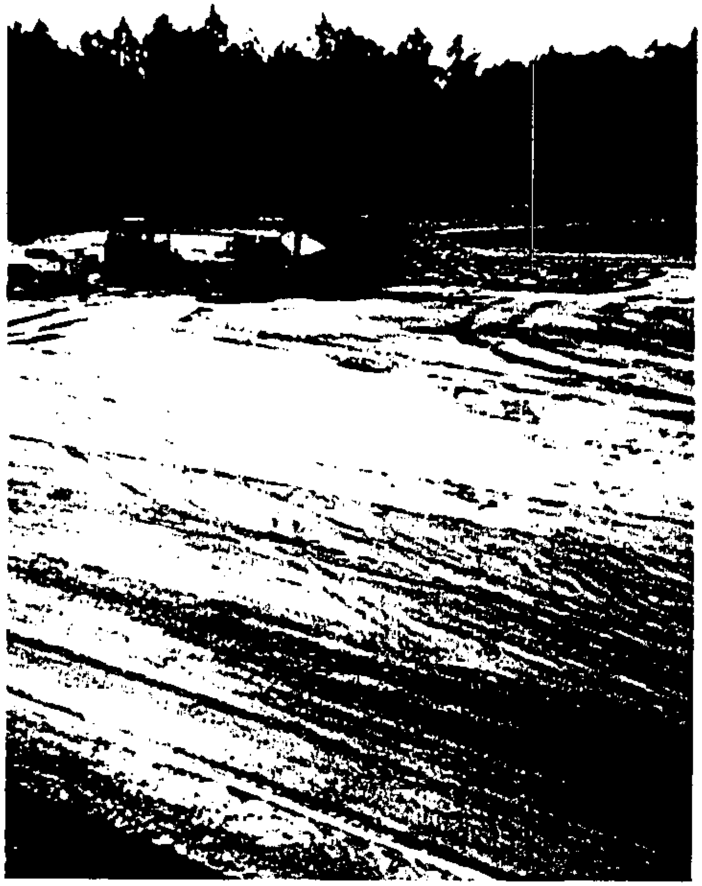


CLAY CAP TEST PROGRAM SITE



GLEASON CLAY SHREDDER

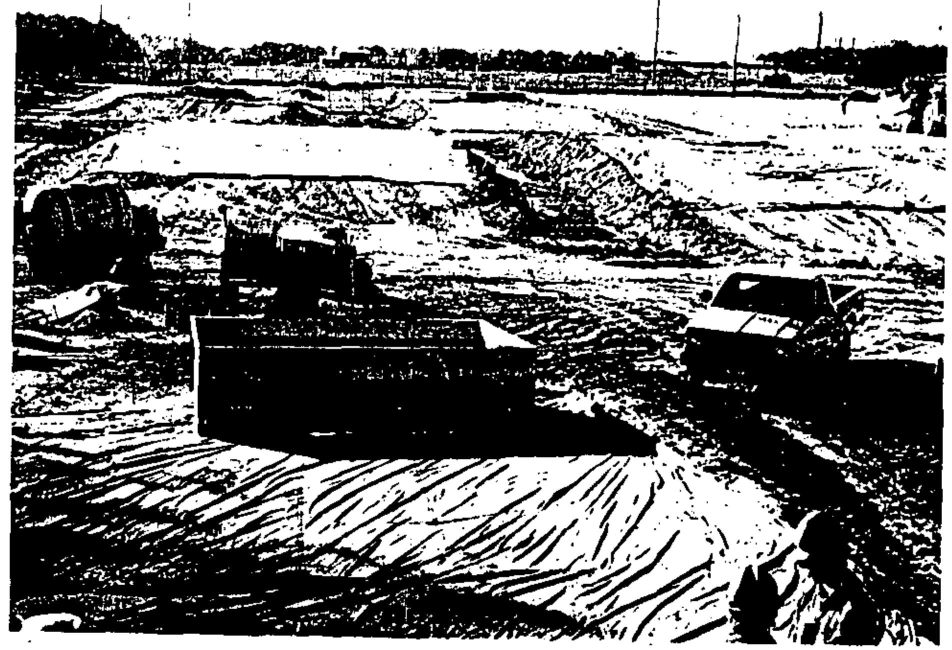



KAOLIN CLAY DELIVERY

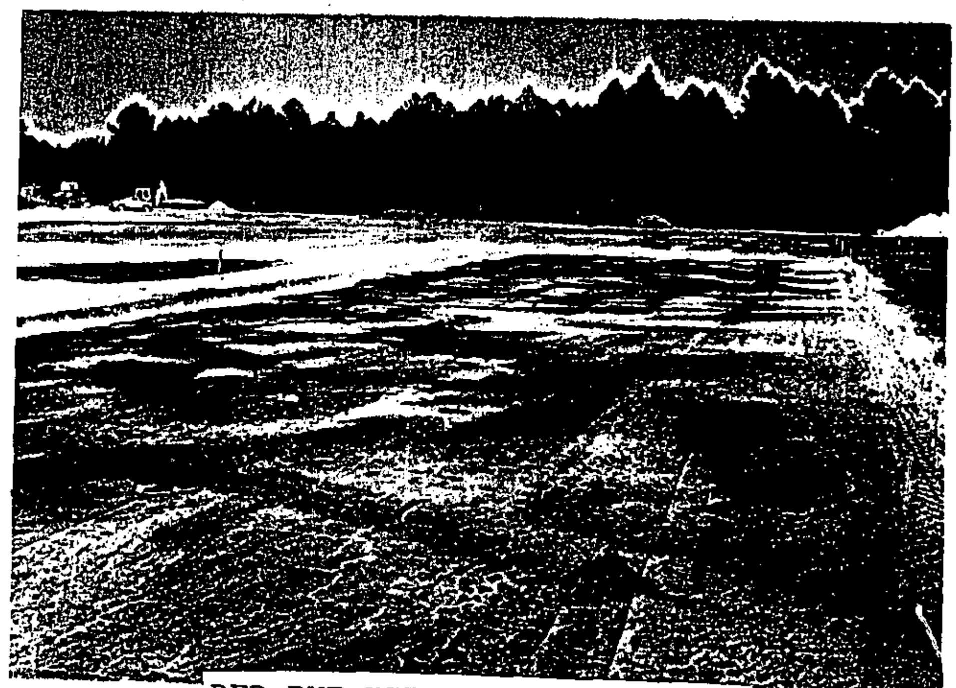

GLEASON CLAY SHREDDER


SIZE REDUCTION OF KAOLIN CLAY

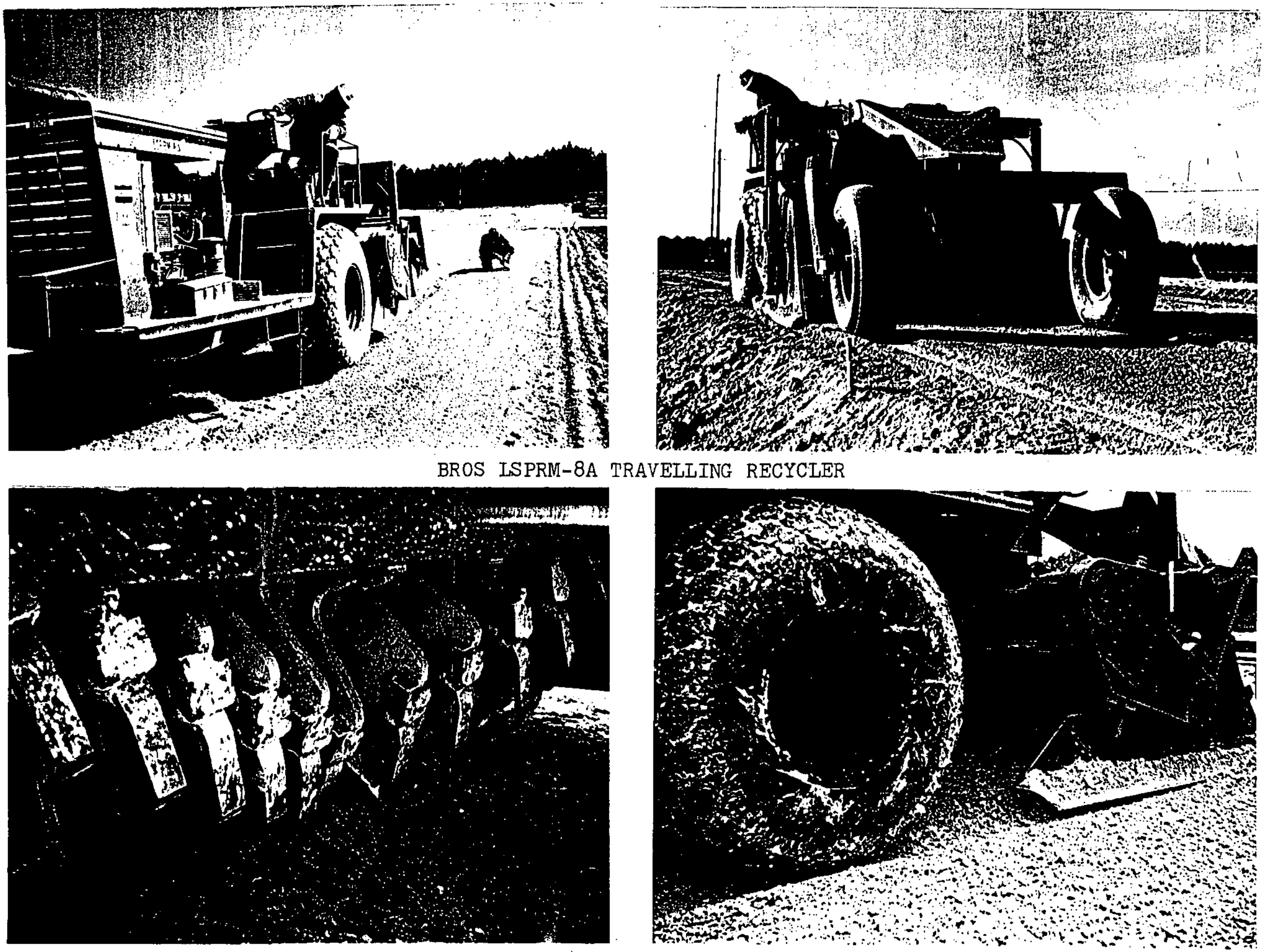
CURING CONDITIONED KAOLIN CLAY



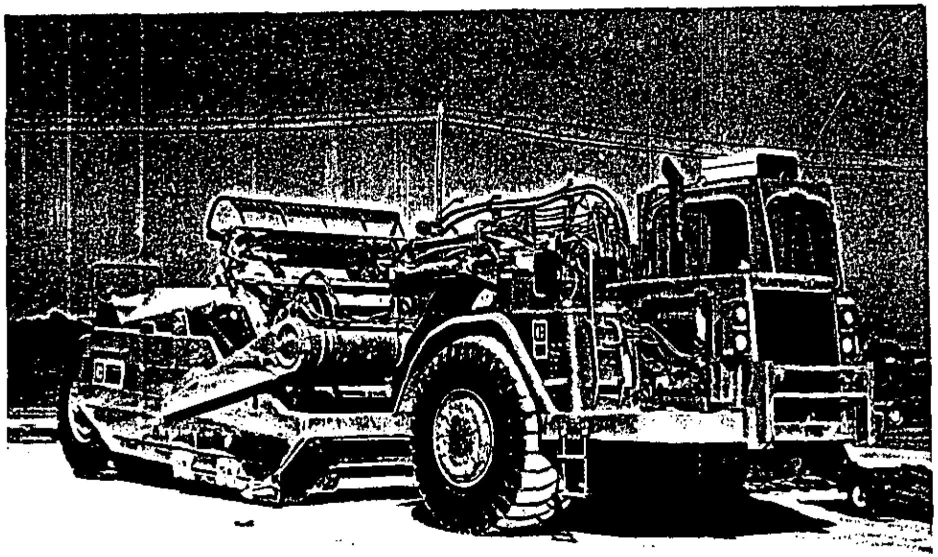
KAOLIN CLAY TEST PANELS



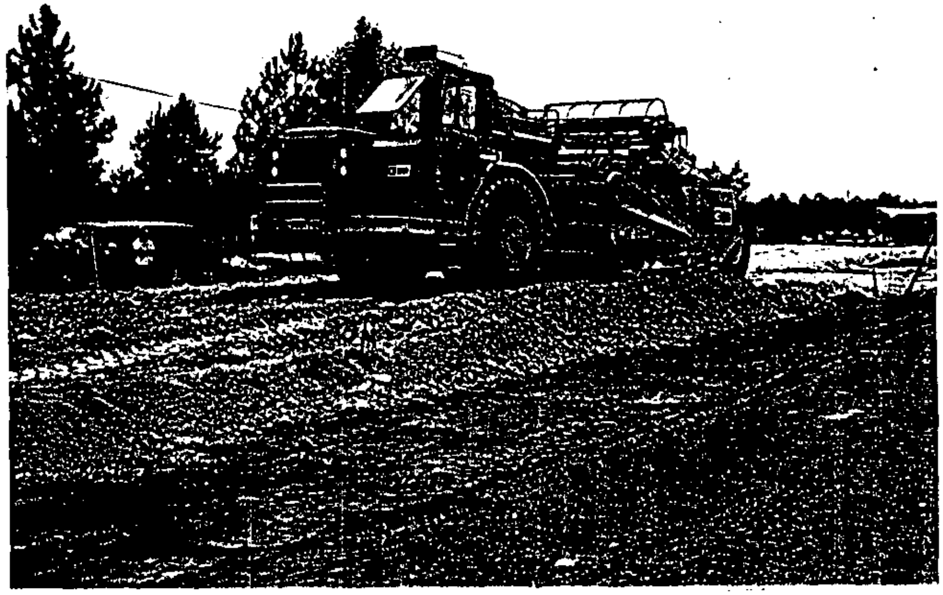
RED DYE USED IN CONDITIONING
AREA TO IDENTIFY LIFTS



BROS LSPRM-8A TRAVELLING RECYCLER



CAT PAN USED TO TRANSPORT CONDITIONED CLAY



PAN PLACEMENT OF CONDTIONED CLAY IN LIFTS

GRADING OF CLAY LIFTS

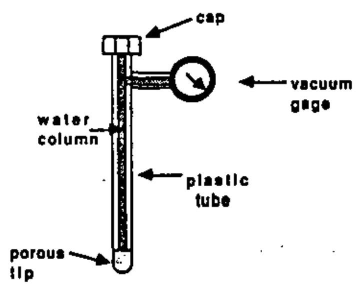
MOISTURE HYDRATION OF TEST PANELS USING WATER WAGON


GRADER SCARIFICATION BETWEEN LIFTS

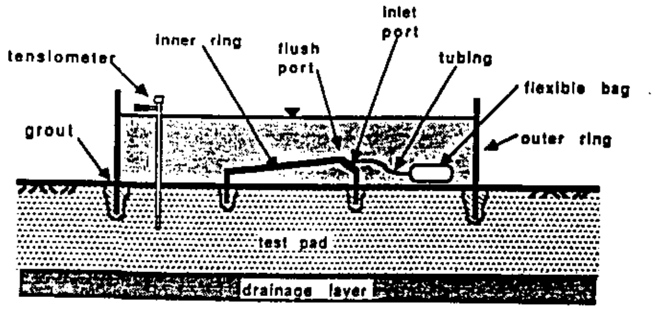

8" COMPACTION FOOT IMPRINTS
TIES LIFTS TOGETHER

CAT 815B SHEEPSFOOT COMPACTER

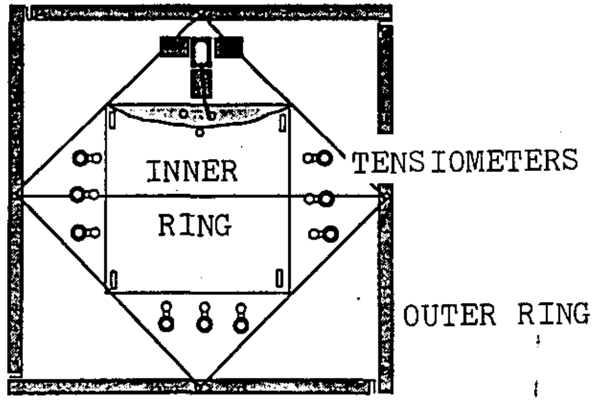

COMPACTION OF KAOLIN CLAY



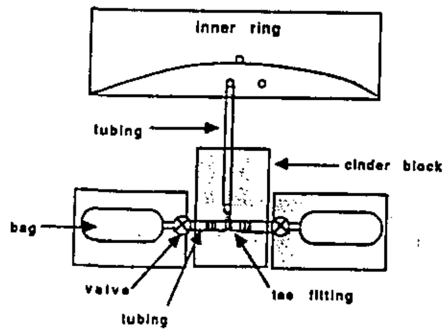
SCHEMATIC OF A TENSIOMETER



SCHEMATIC OF A SEALED-DOUBLE RING INFILTROMETER INSTALLED ON A TEST PAD



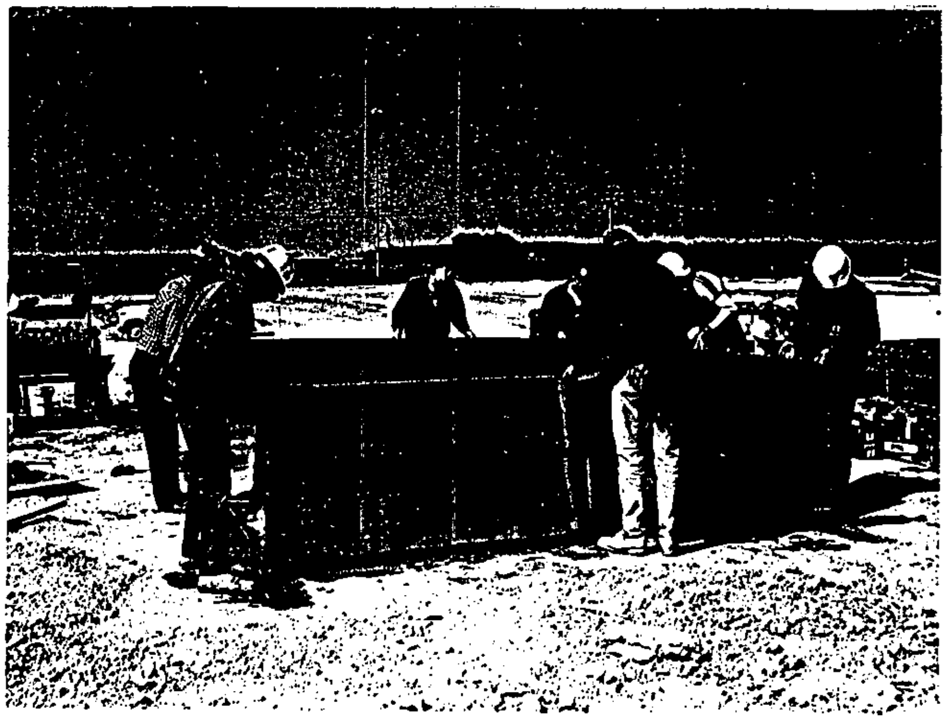
PLAN VIEW OF TRAUTWEIN TYPE SEALED-DOUBLE RING INFILTROMETER UNIT SHOWING LAYOUT OF TENSIOMETERS



ARRANGEMENT OF TWO BAGS CONNECTED TO INNER RING

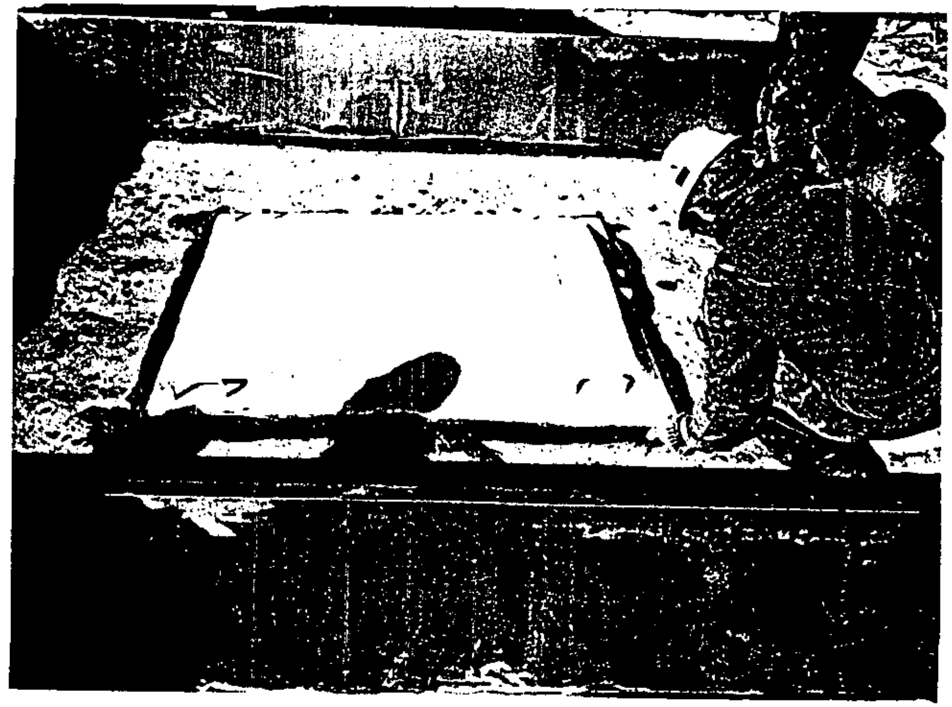
CUTTING CLAY FOR OUTER
RING WITH DITCH WITCH

CUTTING CLAY FOR INNER
RING WITH CHAIN SAW

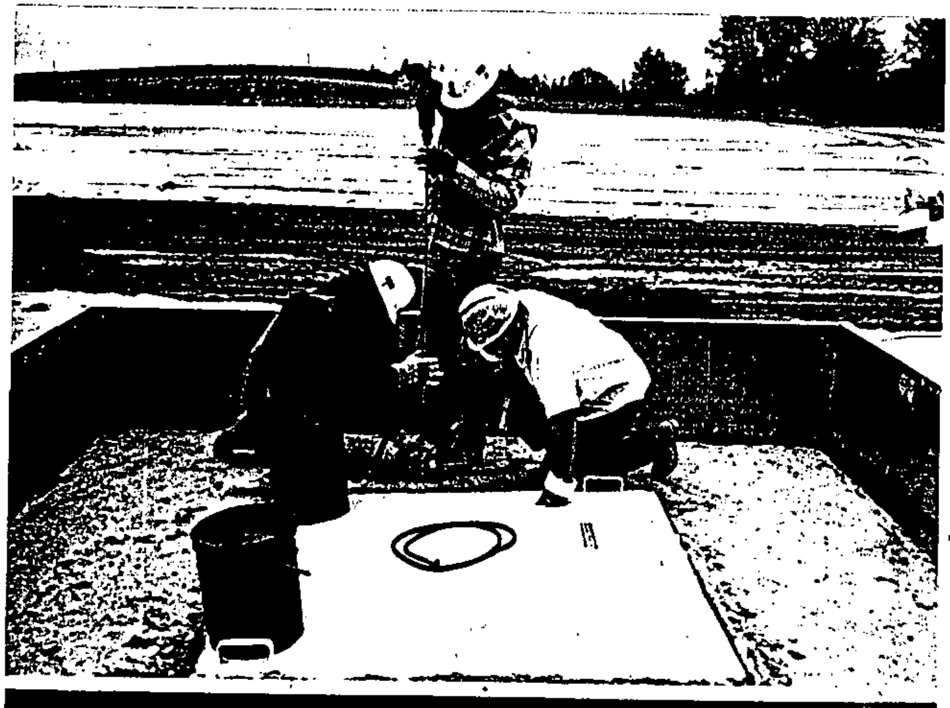


INSTALLING OUTER RING

GROUT SEALING OUTER RING

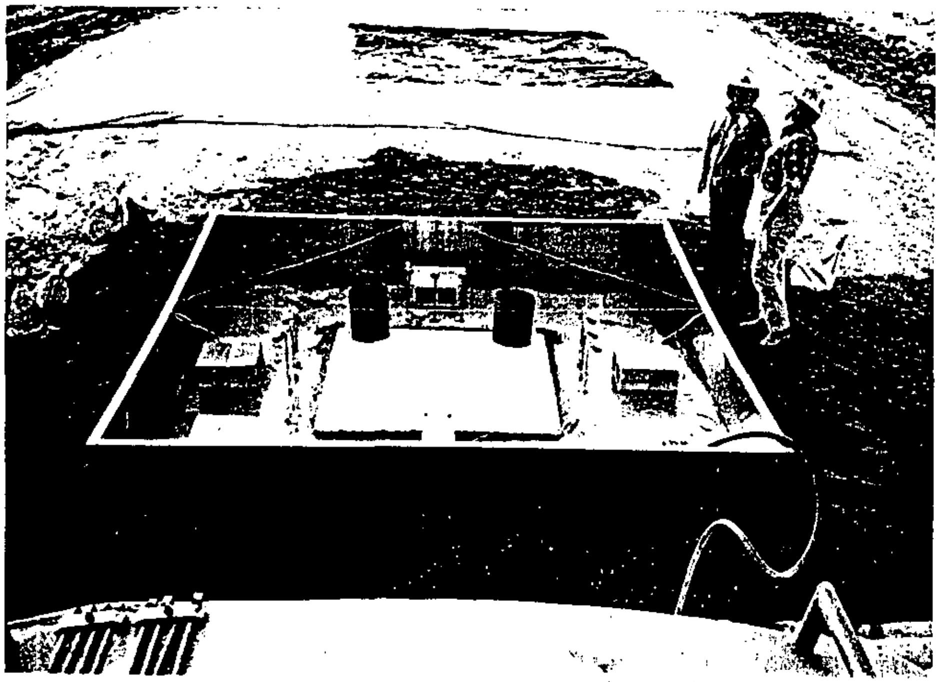
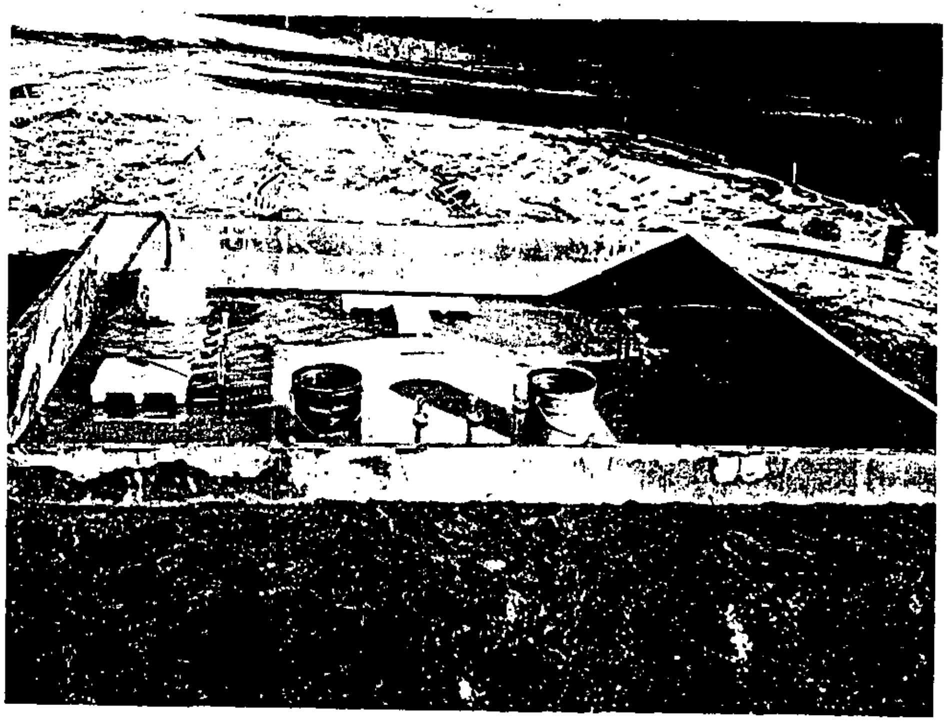


GROUT SEALING INNER RING

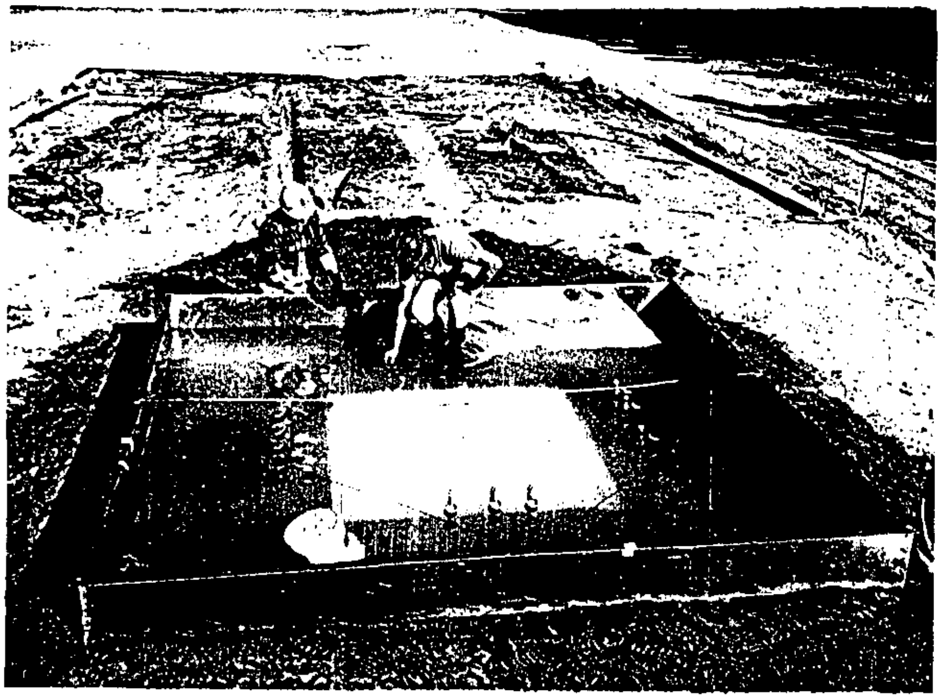


DRILLING TENSIOMETER HOLES USING TRIPOD

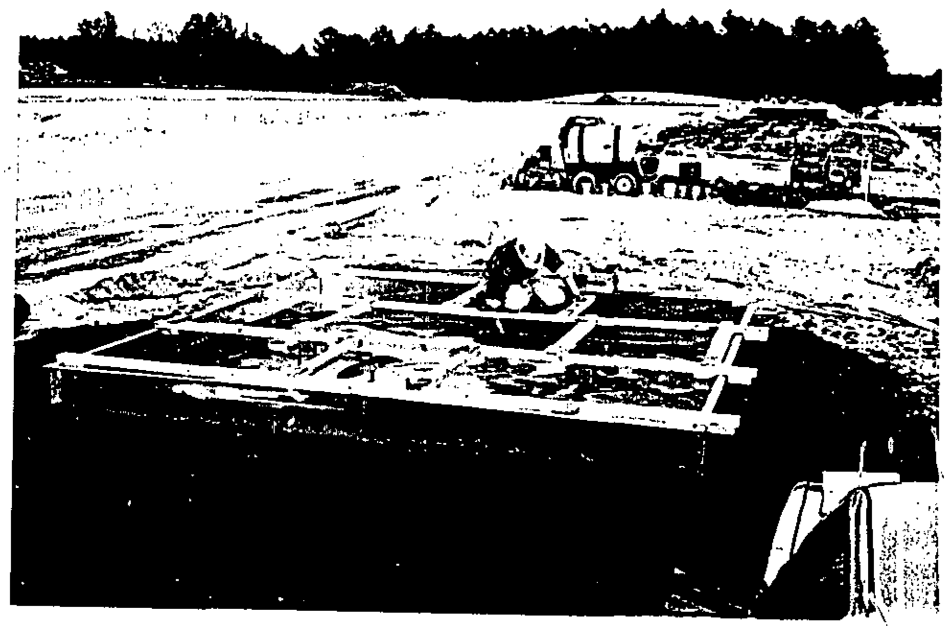
GROUT SEALING TENSIOMETERS (6",12", & 18")

FILLING COMPLETED SDRI UNIT WITH WATER



INSPECTION OF VALVE FITTINGS



FRAME READY FOR COVER

CALCULATION OF INFILTRATION RATE AND HYDRAULIC CONDUCTIVITY

The calculation of infiltration rate(I) is straight forward and is determined as follows:

$$I = Q/(A\,t)$$

where:

- I = infiltration (cm/sec)
- Q = volume of flow (cm3)
- A = area of flow (cm2)
- t = time interval in which Q was determined (sec)

The calculation of hydraulic conductivity (k) is also straight forward and can be determined as follows:

$$k = Q/(i\,A\,t)$$

where:

- Q = volume of flow (cm3)
- A = area of flow (cm2)
- t = time interval in which Q was determined (sec)
- i = gradient
- = $\Delta h / \Delta s$
- Δh = head loss
- Δs = length of flow path for which Δh is measured

since:

$$I = Q/(A\,t)$$

then:

$$k = I/i$$

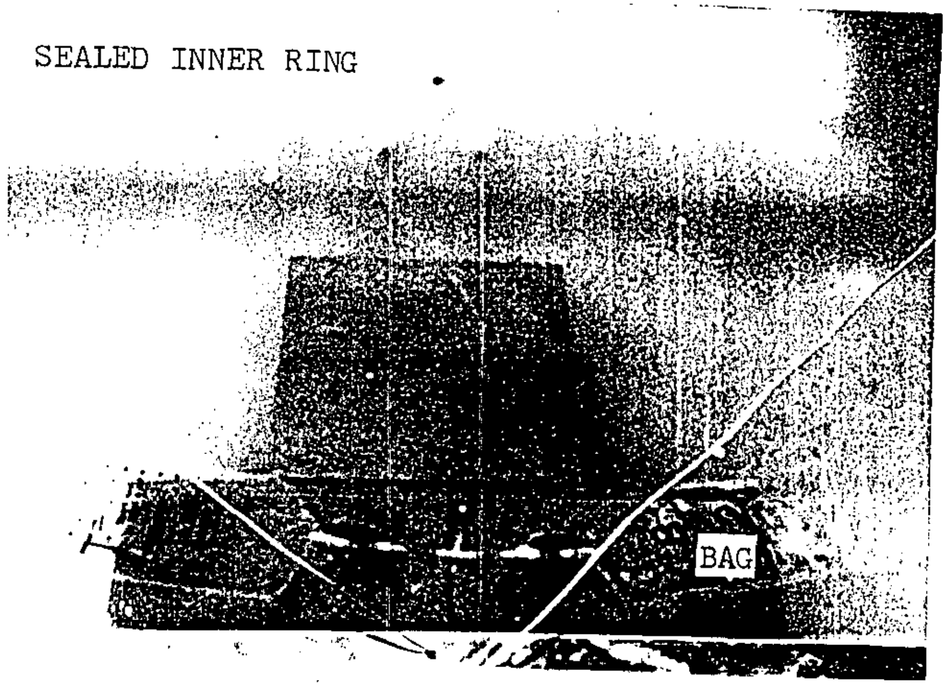
Unlike the calculations for I and k, the determination of i is not straight forward. The parameters used to calculate i for a typical test pad installation are shown in Fig. 3. The gradient is calculated as follows:

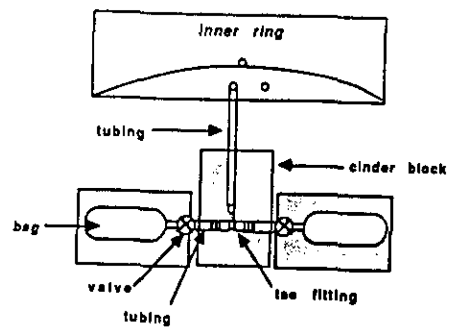
$$i = (H + D + Hs)/D$$

where:

- H = depth of water ponded in rings
- D = depth to the wetting front
- Hs = suction at the wetting front

SEALED INNER RING





ARRANGEMENT OF TWO BAGS CONNECTED TO INNER RING

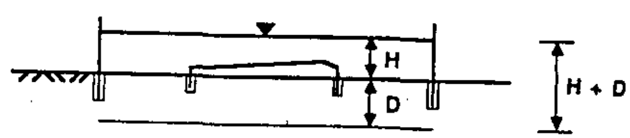


DIAGRAM WITH PARAMETERS

TABLE R-21

SUMMARY OF INFILTROMETER TEST DATA

PANEL NO.	KAOLIN CLAY TYPE	START OF TEST	NO. OF TEST DAYS	AVERAGE WATER CONTENT, W (%)	AVERAGE W - Wopt (%)	AVERAGE % STANDARD PROCTOR COMPACTION	FINAL INFILTRATION RATE (cm/sec x 10-7)	FINAL WETTING FRONT DEPTH (in)	FINAL FIELD PERMEABILITY, K(field) (cm/sec x 10-7)	AVERAGE LABORATORY PERMEABILITY, K(lab) (cm/sec x 10-7)	K(field)/K(lab)
A1	CYPRUS TERT	10/22/87	134	27.0	-1.3	105	2.1	25.0	1.6	0.81	1.9
A2		12/02/87	98	30.8	2.0	100	0.40	25.0	0.32	0.28	1.1
B1	DIXIE TERT	10/15/87	141	29.6	1.5	94	0.96	20.5	0.61	0.34	1.[illegible]
B2		10/28/87	124	30.7	3.6	98	0.85	23.0	0.56	0.25	[illegible]
B3		01/12/88	101	29.4	2.9	98	1.3	28.0	0.91	0.27	[illegible]
C1	MUSER TERT	11/16/87	158	26.8	0.4	103	1.8	27.0	1.2	0.34	3.8
C2		11/23/87	106	29.8	2.7	100	0.70	28.0	0.49	0.43	1.2
D1	CYPRUS CRET	11/12/87	117	24.6	3.4	98	5.1	28.5	3.6	1.6	2.3
D2		12/03/87	141	22.7	2.0	97	6.8	34.0	5.0	1.7	2.9

NOTES

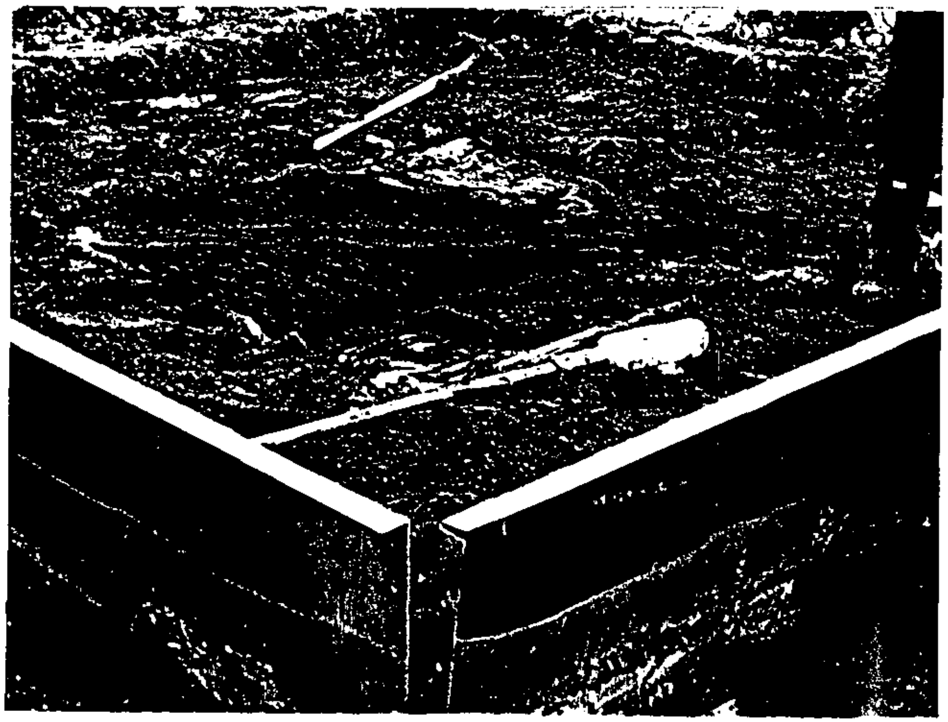
1. All infiltrometer tests performed with a sealed double ring infiltrometer with a 12 foot square outer ring and a 5 foot square inner ring.
2. For all test panels, the final wetting front depth is equal to the total depth of compacted clay fill.

MMHF CLOSURE, CLAY CAP TEST SECTION, SAVANNAH RIVER PLANT

MUESER RUTLEDGE CONSULTING ENGINEERS

FILE # 6524 JUNE 1988

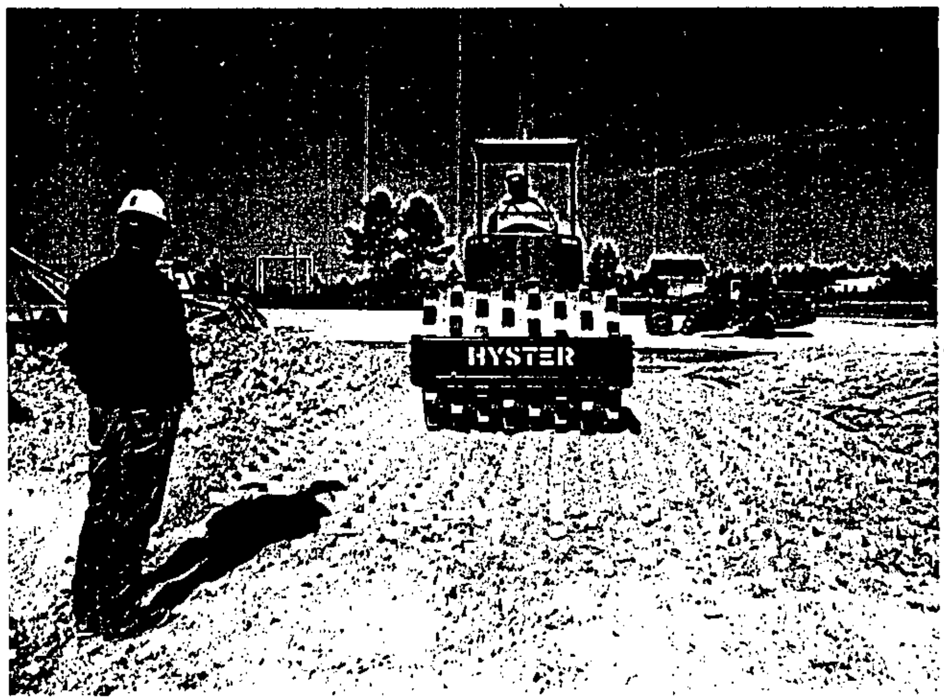
TABLE R-21



PRECIPITATED BLUE DYE ON CLAY SURFACE

POST DISSECTION AND TESTING OF CLAY

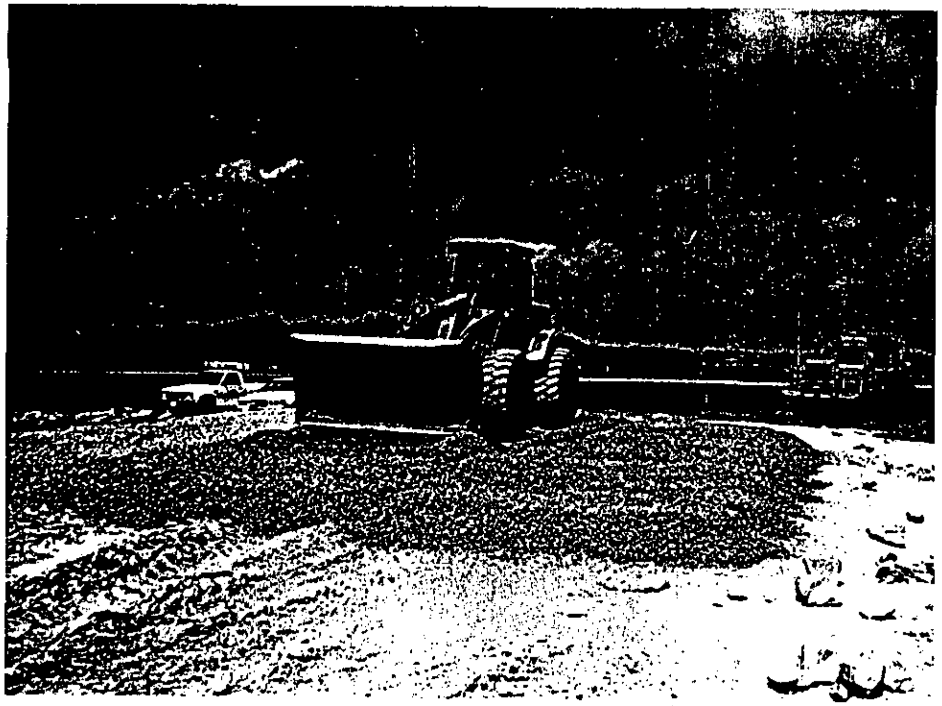
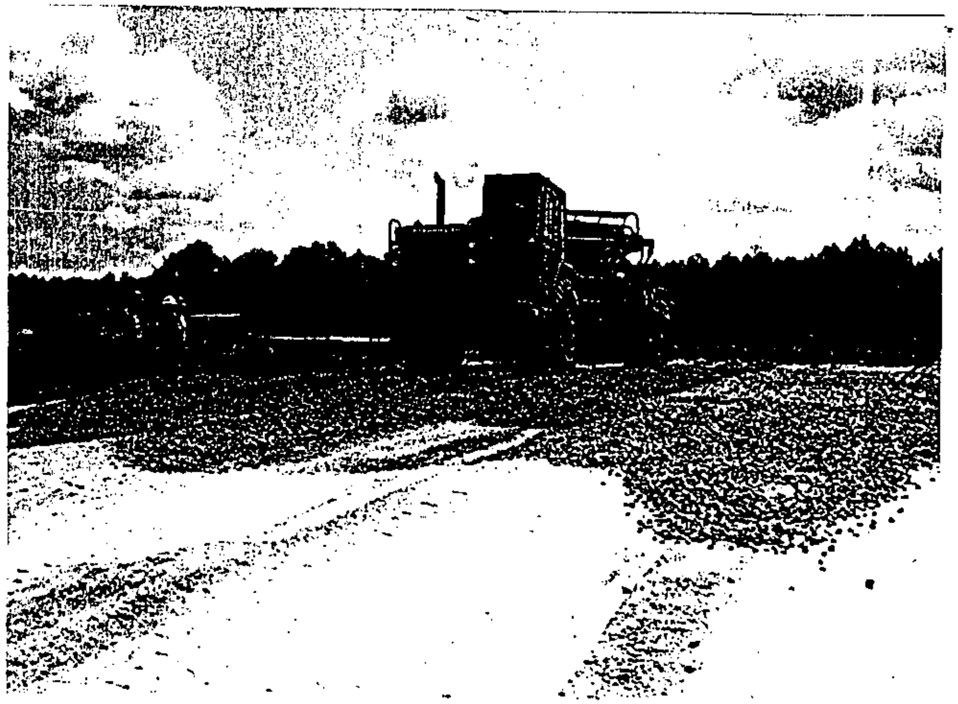
CLAY EXCAVATION



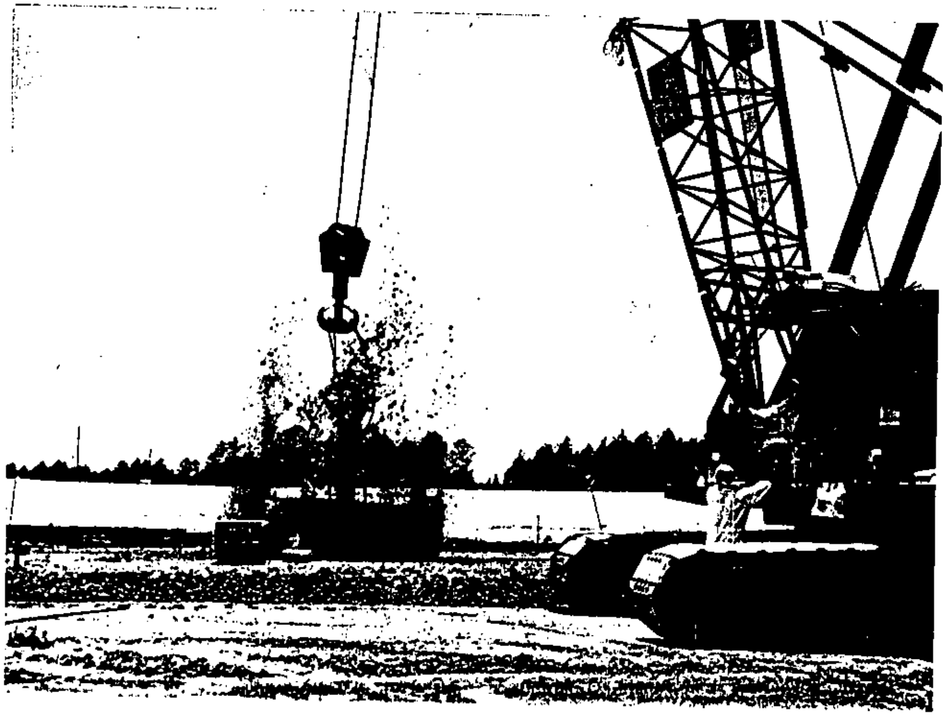
CLAY COMPACTION

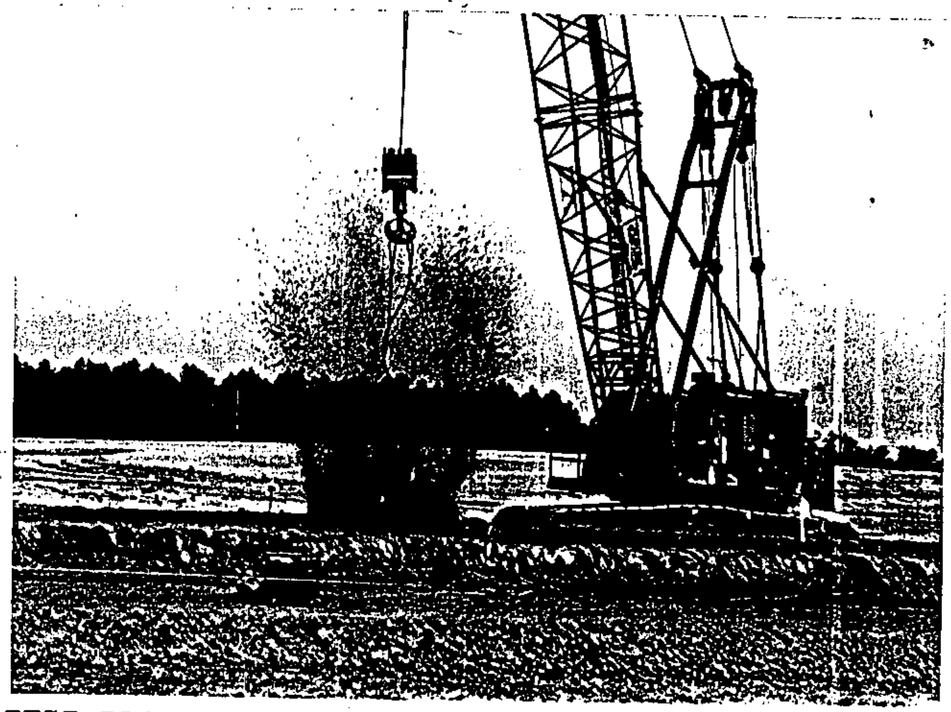
DENSITY TESTING

CLAY TEST REPAIR SECTION

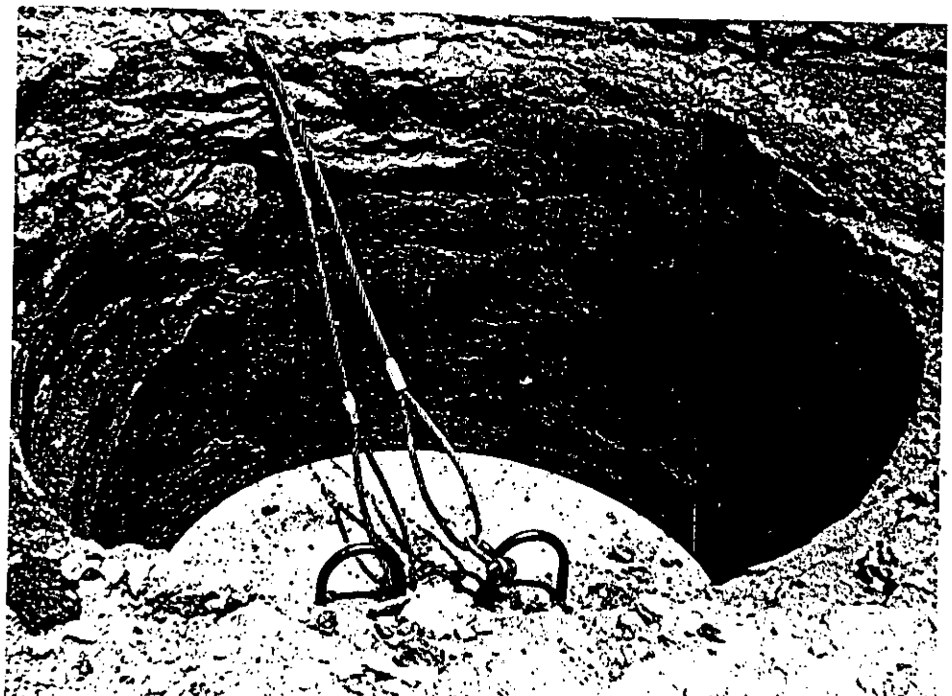



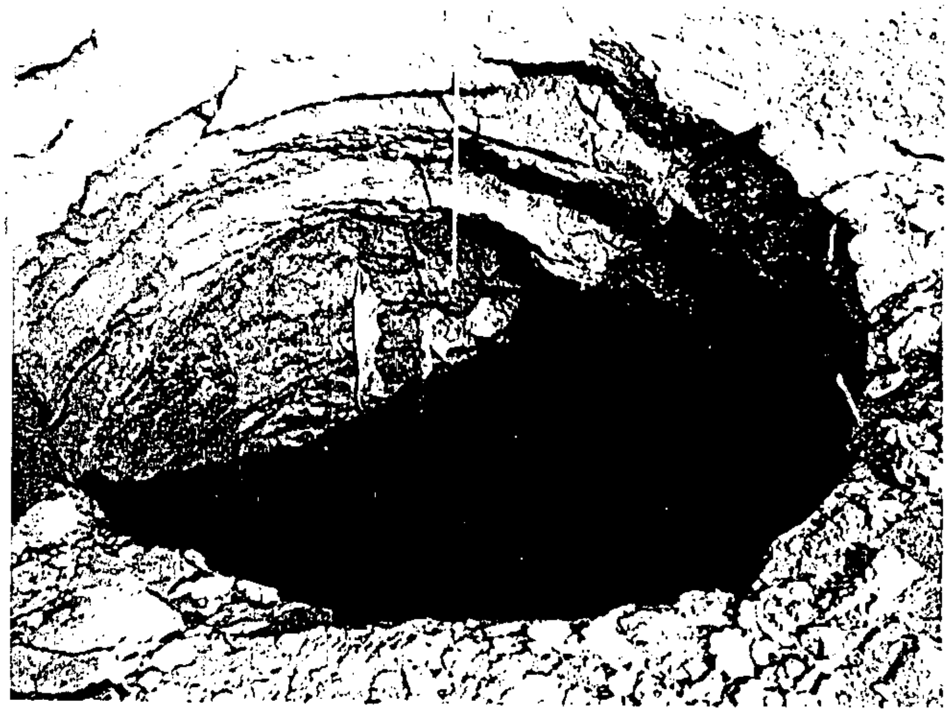
GRAVEL/CLAY PENETRATION DEMONSTATION

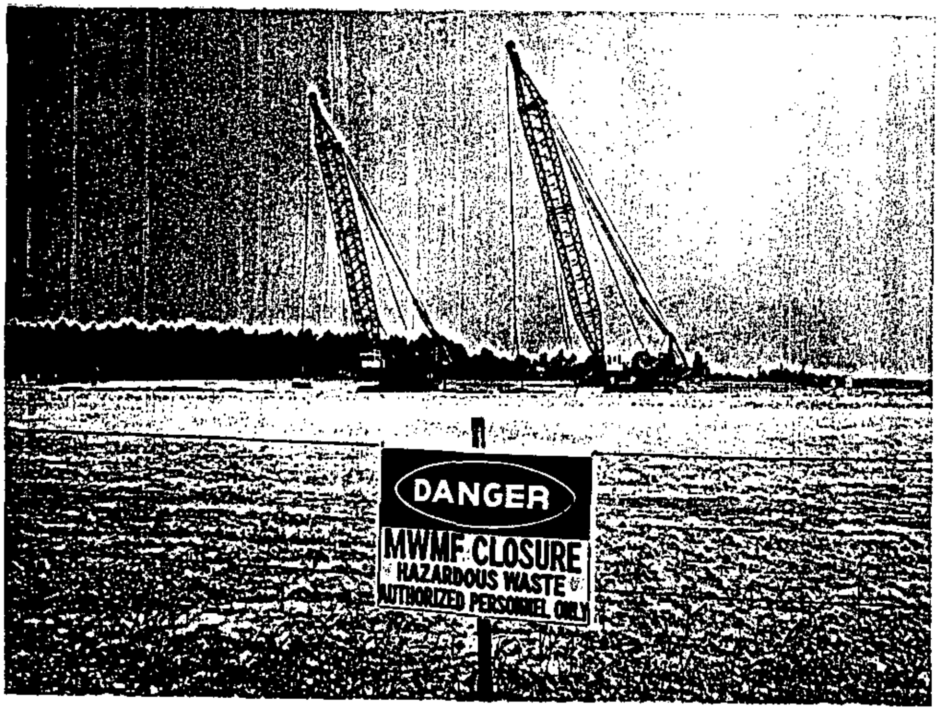


DYNAMIC COMPACTION TEST PROGRAM

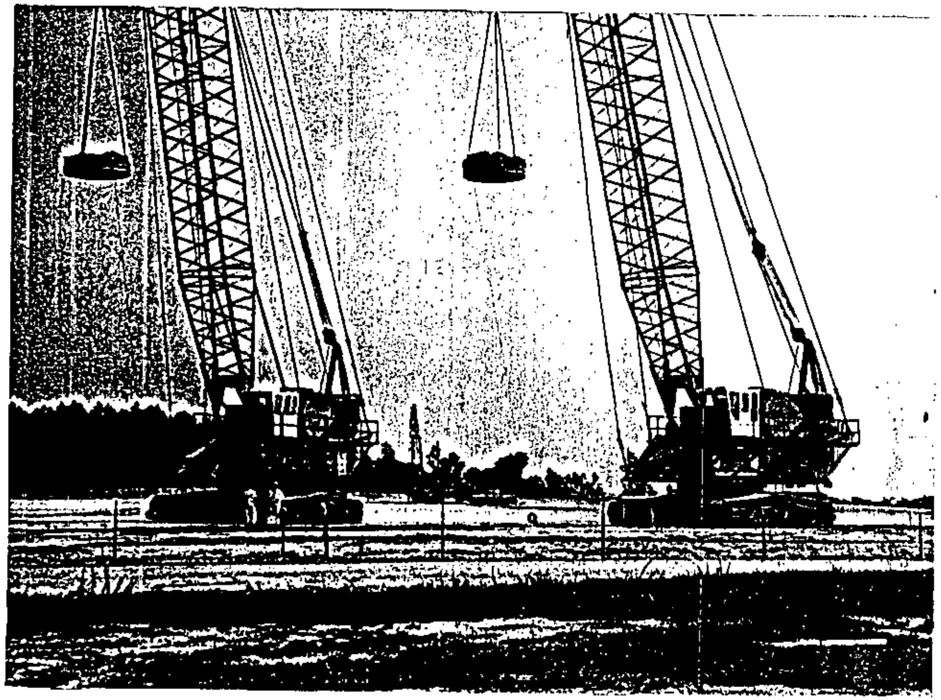




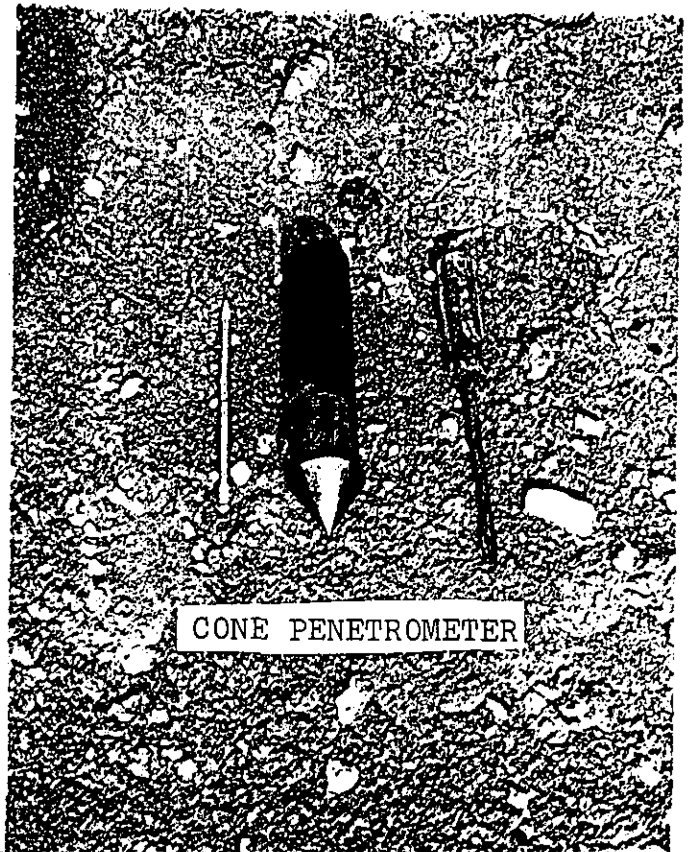
COMPACTED [illegible]IL-WASTE MATRIX IN TRENCHES



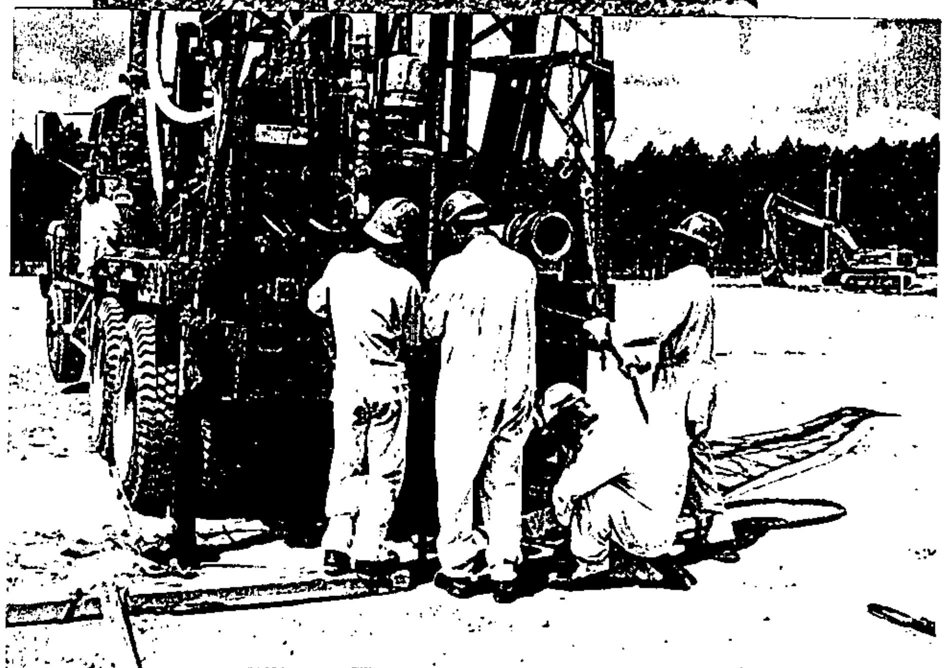
PROJECT PRODUCTION DYNAMIC COMPACTION



LAMPSON "THUMPER" CRANES WITH 20 TON WEIG TS



CONE PENETROMETER



DENSITY VERIFICATION USING PRE AND POST
COMPACTION CONE PENETROMETER METHOD