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CORPS OF ENGINEERS, U. S. ARMY

PRELIMINARY INVESTIGATION OF CHROME-LIGNIN AS A STABILIZING AGENT IN VICKSBURG LOESS SOIL

MISCELLANEOUS PAPER NO. 3-145

A
CORPS OF ENGINEERS
RESEARCH AND DEVELOPMENT REPORT

PREPARED BY THE

WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

ARMY-MRC VICKSBURG, MISS.

SEPTEMBER 1955

Preface

The investigation reported herein was performed under the authority of Project 8-70-03-002, Solidifying or Stabilizing Soils for Military Operations. Tests were performed during the period from April to June 1955.

Personnel of the Soils Division, Waterways Experiment Station, participating in this investigation included Messrs. W. J. Turnbull, W. G. Shockley, J. E. Mitchell, and G. R. Kozan. This report was prepared by Mr. Kozan.

Contents

PRELIMINARY INVESTIGATION OF CHROME-LIGNIN AS A STABILIZING AGENT IN VICKSBURG LOESS SOIL

Introduction

1. This report describes a preliminary laboratory investigation to determine the suitability of chrome-lignin as a stabilizing agent for Vicksburg loess soil. Since the chrome-lignin used in this study had been stored at Ft. Belvoir, Va., for a long period of time and required grinding prior to use, the "potency" or stabilizing capacity of the chemical was subject to question. Consequently, this investigation was limited primarily to evaluation of the chemical quality of the stabilizing agent prior to the performance of more extensive laboratory studies.

Materials Used in the Investigation

Soil

2. The soil used in this study was Vicksburg loess, an inorganic silt of slight plasticity (ML), which has a liquid limit of approximately 29 per cent and a plasticity index of 4. Maximum dry density (standard Proctor compaction) of the material is 104 lb per cu ft at an optimum moisture content of 18 per cent. A more complete description of the soil characteristics is not believed pertinent to this study.

Chemical

3. The chrome-lignin process is based on the reaction of a water solution of lignin sulfonate, contained in a waste product of the sulfite paper process, with a hexavalent chromium compound such as sodium or potassium bichromate. The result is a nearly water-insoluble gel which has a binding action on the soil particles. It is believed that, in fine-grained cohesive soils, a coordination reaction occurs between the chromium atoms and oxygen atoms in the lignin sulfonate and on the surface of the soil particles which affords added binding strength. In addition, the chromium further reacts to form a continuous skin around each soil particle through chromium-oxygen bridges which renders the soil

water-repellent. By altering the formulation of the chemical, it is possible to vary the setting time of the gel and significantly change the properties of the treated soil.

4. The chrome-lignin used in this study was left over from previous work conducted in 1952 by the Engineer Research and Development Laboratories, Ft. Belvoir, Va. The chemical had been stored outdoors in paper bags and covered with a tarpaulin; however, because of its deliquescent characteristic, sufficient moisture had been absorbed to form a hard consolidated mass. Two hundred pounds of this hardened material was processed in a reduction mill (at the Waterways Experiment Station) to a fineness sufficient to pass the No. 50 standard sieve. The quality of the chemical could not be determined from the appearance of the ground material. The formulation of this chemical is as follows:

Chemical	Parts by Weight
Sulfite waste solids (Bindarene flour)	4
Potassium bichromate, $K_2Cr_2O_7$	1
Aluminum sulfate, $Al_2(SO_4)_3 \cdot 18H_2O$	1

5. To determine if the chemical was still reactable, a 30 per cent solution was prepared with distilled water and the setting or "gel" time was observed. The time of initial "set" was about two hours which is slightly longer for this concentration than that obtained previously in Cornell University studies*. This difference in setting time indicates that some impairment of setting ability was probably caused by either the initial hardening during storage or deterioration of the chemical with age. However, since the final gelled material appeared normal, it was decided to continue the test utilizing the chemical on hand.

Preparation and Testing of Specimens

6. Specimens were prepared using a 7.5 per cent chrome-lignin

* Cornell University, Final Report, Soil Solidification Research, September 1951.

treatment (by dry weight of soil) and compacted by standard Proctor procedure at initial moisture contents of 15 and 20 per cent. The soil was brought to the required moisture content and chemical in the powder form was added. This mixture was then hand-blended for a minimum of five minutes to insure homogeneity before compacting. Four specimens were thus prepared at each moisture content and two of each group were allowed to air-dry for a period of 24 hours and two for a period of 7 days. Then one specimen of each group was totally immersed in water for 24 hours following the air-dry period. Untreated specimens were similarly prepared and cured, but not immersed. All specimens were subjected to an unconfined compression test after completion of the prescribed curing periods. The results of these tests are summarized in table 1.

Discussion

7. Because of the limited data obtained in this preliminary study, little discussion can be offered regarding the effectiveness of chrome-lignin in stabilizing loess soil; however, a few interesting observations warrant brief analyses and some discussion.

Air-cured results

8. It can be seen from table 1 that the lignin-treated specimens exhibit slightly greater compressive strengths (with one exception) than the untreated loess after a similar air-drying period. Further, it is noted that the moisture contents of the cured treated specimens are significantly higher than the moisture contents of the untreated soil cured for the same period. Thus, the higher strengths indicated in the treated soil were realized at considerably greater moisture contents than those of the untreated soil. Insufficient data preclude the definite establishment of strength relationships between the treated and untreated loess.

Revet strength

9. Perhaps the most significant result brought out in this study with respect to quality of the chemical was the high compressive strengths realized after a 24-hr immersion period following the air-drying, which

indicated that the waterproofing ability of the chemical had not been impaired. In the case of the specimens air-dried for 24 hours, the moisture contents increased upon immersion to a value approaching the initial mixing moistures. The moisture contents of the 7-day, air-dried samples, however, increased upon immersion to a value significantly lower than the initial moistures. The compressive strengths obtained after the immersion period were fairly consistent, averaging 70 per cent of the air-dried strength. These results compare favorably with results obtained previously in the Cornell University investigation.

Density and moisture content

10. The data are insufficient to determine what effects, if any, the density and initial mixing moisture content have on the characteristics of the final product. Discussion of the effects of these variables will be reserved until a more comprehensive study of the use of chrome-lignin in loess stabilization is made.

Conclusions and Recommendations

11. It is concluded from this study that:

a. The stabilizing ability demonstrated by the chrome-lignin used in this investigation indicates that it is chemically satisfactory for further use, having suffered little or no loss of potency during storage or reprocessing.

b. Beneficial results were obtained in loess treated with 7.5 per cent chrome-lignin; particularly, rewet strengths definitely indicate an improvement in the strength properties of loess soil.

12. It is recommended that further tests be conducted with loess soil to study the full potential of chrome-lignin as a stabilizing agent for this soil.

Table 1

Summary of Test Results

Specimen	As Molded		As Cured			Rewet		
	Moisture Content %	Dry Density lb/cu ft	Moisture Content %	Dry Density lb/cu ft	Maximum Compressive Strength psi	Moisture Content %	Dry Density lb/cu ft	Maximum Compressive Strength psi
				Untreated				
24-hr air-dry	15.4	102.9	9.5	106.0	112	----	-----	---
24-hr air-dry	20.1	103.8	13.2	109.7	89	----	-----	---
7-day air-dry	15.5	103.7	4.6	104.7	246	----	-----	---
7-day air-dry	20.1	104.0	5.1	113.6	318	----	-----	---
				Treated				
24-hr air-dry	15.5	105.0	12.5	107.6	165	----	-----	---
24-hr immersion	15.7	103.5	----	-----	---	15.2	104.1	116
24-hr air-dry	20.6	99.6	14.9	104.8	108	----	-----	---
24-hr immersion	19.9	100.1	----	-----	---	17.8	102.2	84
7-day air-dry	15.7	103.6	8.6	107.2	306	----	-----	---
24-hr immersion	15.7	103.8	----	-----	---	13.5	106.3	194
7-day air-dry	20.4	100.7	10.2	109.5	278	----	-----	---
24-hr immersion	20.2	100.1	----	-----	---	13.6	107.1	190

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