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Discussions and Replies Session 7

E. C. Shin
Southern Illinois University, Carbondale, Illinois

C. A. Dougherty
University of Missouri-Rolla

Aswath V. Rao
University of Missouri-Rolla

J. Blayne Kirsch
University of Missouri-Rolla

Arthur Pengelly
Hayward Baker, Inc.

See next page for additional authors

Author

E. C. Shin, C. A. Dougherty, Aswath V. Rao, J. Blayne Kirsch, Arthur Pengelly, Kou-Roung CHang, and Kenji Hayashi

DISCUSSIONS AND REPLIES
SESSION VII

Discussion by E.C. Shin
Southern Illinois University, USA

on
Case History of Soil Improvement for a Large-scale Land Reclamation
Paper No. 7.06

Land reclamation project for a steel mill complex was a 6.5 years project which began in January, 1984 and completed in June, 1990. The total reclaimed area was 13.7 km^2 (1.52 x 10^8 ft^2) as shown in Figure 1. The field measurement devices used were as follows: (a) surface settlement plate; 928 EA, (b) layer settlement plate; 25 EA, (c) inclinometer; 53 EA, (d) pore water pressuremeter; 72 EA, (e) ground water level indicator; 25 EA. In all, 2170 soil boring explorations were carried out during these 6.5 years.

Site improvement techniques used in this project were sand drain, sand compaction pile, and preloading. Sometimes preload was applied over the area where sand drains or sand compaction piles were constructed to accelerate the process of the primary consolidation of soft clay and also to reduce the probable settlement. The selection of site improvement method was carefully chosen considering the existing soil conditions as also the future usage of the improved area. The degree of the ground improvement was in the order of preloading method, sand drain method, and sand compaction pile method. The foundation soil around the edge of the structures, such as embankments, crude oil tanks, and ore stockyards, was further reinforced by means of sand compaction piles with pile spacing of 2 m (6.67 ft).

Heaving of clayey soil during the construction of sand pile could lead to pollution problems. This heaving problem can be minimized by advancing the pile driving pattern from the center to the outside of the area to be improved. However, there was no indication of heaving in this project site because most of the construction area was covered by 10 m (32.8 ft) thick sand layer over clayey soil.

The slope stability of the composite foundation was analyzed by both Tshebotariff's method and Bishop's method. The factor of safety calculated by Bishop's method (F.S > 1.3) gave a slightly higher value than that of Tshebotariff's method (F.S > 1.1 - 1.2). However, Bishop's method is more reliable in the area where thick sand layer exists. The typical range of internal friction angle of compacted sand in sand pile was between 30° and 40°.

SPT-N values between 10 and 20 were usually required to insure proper performance of sand compaction piles. After cohesionless soils were improved, SPT tests were performed in between the sand piles and also at the center of the sand piles to guarantee the degree of improvement. Also, after cohesive soils were improved, SPT tests were performed at the center of the sand piles to evaluate the inplace strength of the constructed sand piles. If desired, SPT tests can be performed in between the sand piles in the cohesive soils to better define the shear strength of the improved ground.

Discussion by C. A. Dougherty
Graduate Student, Univ. of MO-Rolla

on
Chemical and Lime Stabilization of Expansive Clay

Paper No. 7.10

In reading the paper by Johnson and Pengelly, a couple of comments come to mind. First, it was noted that the test was performed during September. I assume this is because the natural water content of the soil is lowest at that time. It may be instructive to determine the effect of natural water content upon the performance of the two stabilization methods. This could aid in estimating the effectiveness of these procedures when they are performed during other times of the year, or when given the situation of a homeowner who frequently waters the shrubbery around the foundation of his home.

The other comment concerns relative costs. No mention was made regarding the total volumes of chemical or lime used, and their relative costs. Generally, I would expect the chemical to be the more expensive, but the tests showed that it yielded better results. The question next asked would be how much more lime would be needed to achieve similar performance to the chemical, and at what cost.

Discussion by Aswath V.Rao
Graduate Student
University of Missouri-Rolla

on
Chemical and Lime Stabilization of Expansive Clay

Paper No.7.10

In this paper the Chemical and Lime Stabilization of Expansive Clay done at the San Antonio, Texas area has been discussed. The purpose of the paper was to find a viable method for reducing the excessive differential movements of expansive clays. These clays cause costly damages to structures and pavements in the above region.

The test was performed on a flat field of area 61 by 113 m located at Fort Sam Houston, San Antonio, Tx. The lime slurry and chemical injections were performed in two 7.6 by 7.6 m square test pads located at opposite corners of the flat test area. The samples were obtained approximately two weeks before treatment and two weeks after treatment to provide specimens suitable for characterizing the soil and determining the effectiveness of each treatment.

The gravelly soil, which is considered to be less expansive was about 2.4 m below the ground surface at pad #1 where chemical injection was performed and 2.1 m below ground surface at pad #2 where lime injection was performed. Groundwater was not encountered in any of the boring holes.

The expansive soil at the site above the gravel is a gray-brown clay CH overburden with natural water content 20 % and liquid limit in the range of 60 - 80 % . The natural moisture content prior to treatment were dry of the plastic limits indicating a highly desiccated soil. The expansive soil is rated with high potential for swell from the WES classification system.

The free swell test before the treatment and after the treatment was carried out according to method B of ASTM D4546 to measure the potential swell of the soil. The sample from the shelby tubes were trimmed into consolidation ring. Initial and final water content and Attenberg limits were carried out.

Two passes of chemical injection utilizing a normal full strength concentration of chemical were injected at 345 kPa. Injection was conducted at a spacing of 0.9 m such that the final center-to center spacing was approximately 0.6 m. This method reduced the potential for swell from 6 to 10 percent to less than 1 percent. Both pressure swells and free swells were used to measure swell. The Attenberg limits indicated that the chemical treatment had increased the plastic limit, but the liquid limit of the soil had not altered. The soil water content was increased due to the chemical treatment.

Four passes of lime injection at 325 to 1300 kPa were completed. Injection was conducted at a spacing of 1.5 m such that the final center-to-center spacing was approximately 0.75 m. The mix contained approximately 0.2g of lime per cc of slurry. The results of the lime stabilization showed that swell was reduced from 5 to 7 percent to a range that varied from 5 to less than 1 percent, except for the data point of the test conducted at 1.8 m. This variation is due to the lime not actually entering the sample.The soil moisture content also increased by lime injection.

The author points out that chemical stabilization is considered a direct stabilization method where mineralogical changes occur in the clay that reduce it's tendency to swell. The lime stabilization is considered a preswelling technique because, although some stabilization does occur, it is hard to quantify. The author would have given a estimate of the cost difference between these two methods. Also, he would have given some idea to the readers of the paper about the advantage of the two methods above the another.

Discussion by: J. Blayne Kirsch
UM-Rolla: Geological
Engineering
Graduate Student

on
Foundation Soil Preparation for Landfills in Karst Terrain

Paper No. 7.17

The foundation soil preparation activities have been explained for a sanitary landfill expansion (8.8 acres) in a well-developed karst region of north central Florida. The Alachua formation consist of 10-20 feet thick of alluvial material. The Alachua formation is underlaid by the karstified limestone of the Crystal River formation (CRF). The depth of the Alachua formation ranges from 0-14 feet below the bottom of the landfill.

A foundation investigation was conducted to identify karst features. The investigation consisted of subgrade pre-rolling with 15 ton or heaver vibratory roller and ground penetrating radar (GPR). The GPR and cone penetrometer tests (CPT) identified 43 karst anomalies within the Alachua formation. The anomalies were filled with compaction grouting. Vibratory compaction was conducted in areas that had received injection grouting.

The depth of CRF is 10-20 feet below the base of the cell on the west side. The investigation concluded that grouting was not economically feasible in the karstified CRF. Further information is requested for not filling in karstic features in the CRF west of the centerline of the cell. The possibility of the shallow karst feature in the CRF could inducing foundation instability could be expanded on. Also, data concerning the cost of the injection grouting for the less than 15 foot, 15-20 foot and greater than twenty foot diameter anomalies that were grouted would be beneficial.

Discussion by Wu

on
"Field Measurements of a Diaphragm Wall Foundation"

Paper No. 7.28

1. This paper wants to perform the behavior of the excess pore water pressure when the diaphragm wall foundation is built. In the fig. 5 and 6 we can find the pore water pressure will increase when the bucket movement. Can we find the relationship between the rate of pore water pressure increasing and the impact energy of bucket movement?

2. In p. 1059 a deep well and a device, water-cut-off-packer, is set up to dissipate the generated excess pore water pressure. How to monitor the improvement of the device? Can this device dissipate excess pore water pressure in time? Can we be sure that the excess pore water pressure won't influence trench wall?

Replies by Eun C. Shin
Southern Illinois University, USA

on

Paper No. 7.06

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Replies by Arthur Pengelly
Project Manager, Hayward Baker, Inc.

on

Paper No. 7.10

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The effect of natural moisture content does effect the performance of any type of injection stabilization. The drier the soil when the injection is performed, the more effective the injection will be. A study of this condition would be informative and may be considered as part of this ongoing program.
In order to make the lime treatment achieve the same results as the chemical it would have been necessary to perform more injections. Even though more injections could have been performed at this site they may have not been able to acheive the level of swell reduction accomplished by the chemical which happens at some sites. Preswelling is sometimes difficult to accomplish in certain soil formations.
The cost of the chemical injection is $0.30 per cubic foot in the San Antonio area. The cost for the lime treatment would range from $0.08 to $0.12 per cubic foot depending on the level of treatment necessary to reduce the swell of a specific site to acceptible limits. The advantages of preswelling is obviously the cost. If a site is easily preswelled and the type of building that is being constructed can withstand movements of up to an inch, such as a warehouse then preswelling would probably be the method of choice.
In structures that cannot withstand movements the chemical would be the correct choice because of its consistent ability to reduce swell to a predictable limit. While it is more expensive than lime treatment it is worth the price because of its effectivness. Chemical injection is also cheaper than removing comparable amounts of soil and replacing it with high quality fill.

Replies by **Kou-Roung Chang**
CH2M HILL

on

Paper No. 7.17

Local geological and grouting experience indicate the limestone cavities in the Crystal River Formation are well connected. Grout under pressure was discovered as far as 50 feet away from the grouting location. Therefore, grouting all the cavities under the entire landfill to as deep as 100 to 150 feet below the ground surface is not economically feasible. At the Southwest landfill, the purpose of the compaction grouting was to densify the sand-filled chimneys above the Crystal River Formation and to prevent the collapsing of the chimneys.

The payment for the grouting was based the volume of grout intake, independent of the depths of the boreholes. In 1990, the grouting cost was at approximately $100 per cubic yard.

Replies by Kenji Hayashi, Chuo Fukken Consultants Co.Ltd

on

Paper No.7.28

We have performed a bucket falling test to confirm the effectiveness of the deep well. The bucket falling test was performed at some depth when the excavation was temporarily suspended as shown in Fig.1. In this test, the relationship between the quick falling height of the bucket and the change of excess pore water pressure was tried to clarify by operating a device of water-cut-off-packer to open or shut.

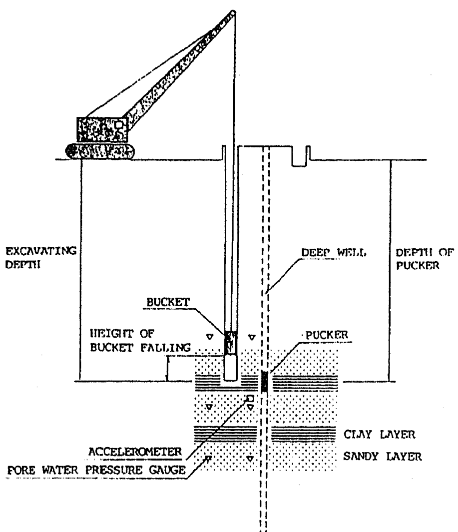

Fig.1 Bucket falling test

Fig.2 shows the relationship between the height of bucket falling and the change of excess pore water pressure at the excavation of GL-37m. This result give us an answer to the discussion, as follows:

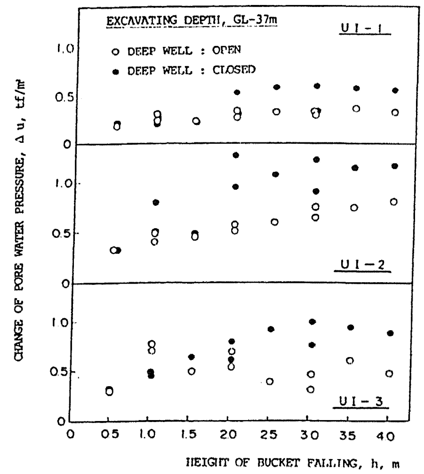

Fig.2 Relationship between height of bucket falling and change of excess pore water pressure

1. The height of bucket falling can be considered an index of the impact energy of bucket movement. As shown in Fig.2, the greater the height of bucket falling becomes, the greater the change of excess pore water pressure.

2. We confirmed the change of excess pore water pressure without deep well is about double of that with the deep well, as shown in Fig.2. Therefore, we concluded that the deep well could dissipate the excess pore water pressure in time.

Reference

T.Matsui et al.(1993), "Field Measurements and Analysis on a Diaphragm Wall Foundation", Proceedings of the Second Kansai International Geotechnical Forum on Comparative Geotechinical Engineering, JSSMFE, Japan, PP 89-99.