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SHEAR STRENGTH CHARACTERISTICS OF HEAVILY GLACIATED SOILS OF CHUGACH RANGE

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ABSTRACT

As a part of the evaluation of the stability of cut slope of 55% grade, during the construction of Trans-Alaska pipeline, it was realized that the estimation of the strength characteristics of the glaciated till forming the slopes is vital to the analysis and the design of these slopes. Accordingly undisturbed samples were hand carved from block samples and were tested fro shear strength. An usually high effective angles of friction, 45˚ - 48˚ (Singh, 1976) were obtained. However, these high values of friction were found to be inconsistent with the maximum angle which the cut slopes can withstand. The paper presents the results of tests and analysis and explains the unusual behavior and bring into focus the special considerations required in extending methodology of temperate regions to slopes of cold regions.

INTRODUCTION

The effect of construction on the stability of soils of Alaska and Canada has been the subject of study during the past several years. New concepts have emerged as a result of realization that existing expertise and understanding of soil behavior in temperate climates is only partly applicable in analyzing the behavior of soils in cold regions.

The 1,200 mm diameter oil pipeline from Prudhoe Bay to Valdez in Alaska and its associated facilities was the largest construction projects of its time ever undertaken by private industry. The approximately 1207 Kilometers (750 miles) long pipeline route traversed a wide range of geologic regions like permafrost of the North Slope and the arid conditions in the Chugach Mountains near Valdez. Some unusual geotechnical problems were presented by these regions. This paper deals with the evaluation of the stability of cut slopes made in the heavily glaciated soils of the Chugach Mountain region. The difficulties in estimating the shear strength characteristics of the glacial till, for use in the design of cut slopes, are described. In spite of the unusually high friction angles of glacial till, the interference by the existence of seeps and springs of the Chugach range in the evaluation of the stability of the slopes is also presented.

THE SOILS OF THE CHUGACH MOUNTAIN RANGE

The subsurface profile was established based on data from drilling records. The overburden soils on the sloping bedrock consisted of varying thicknesses of dense to very dense dark gray silty and sandy gravel with some cobbles and angular gravels up to 3 in each size. In general, moisture contents, except during spring melt are low and the dry densities are exceptionally high.

Typically there is a strong interlocking of the particles in these soils. There appeared to be a very high degree of overconsolidation. However, it could not be quantitatively measured in the laboratory because of the small amount of fines in the soils tested.

EVALUATION OF THE SHEAR STRENGTH OF THE GLACIATED SOILS

It was apparent that the estimation of the strength characteristics of the till forming the slopes is vital to the analysis of design slopes of 55% grade. However, it was not easy to sample, using conventional means the Chugach glacial till because of its extremely dense, gravelly and cobbly nature. Accordingly large undisturbed blocks were secured first and then by using extreme care and effort were shipped to San Francisco laboratory testing. Six inch diameter samples were hand carved from these blocks and were tested under triaxial compression testing. The dry densities of these samples were exceptionally high (130 p.c.f.) and the particles were strongly interlocked.

Consolidated undrained tests were run at consolidation pressures ranging from present overburden to 5 tsf. Strength parameters were estimated from Mohr envelopes drawn for the failure criteria corresponding to maximum principal stress difference and maximum principal stress ratio. Effective angles of shearing resistances were found to be as high as 48º. For the values of effective strength parameters ranging from Φ

= 38˚ to Φ = 48˚, a typical average value of Φ = 45˚ was used in the stability analysis. This value was considered satisfactory for shallow failures under low confining pressures because the high effective angles of friction and zero cohesion should preclude the possibility of a deep seated failure. The total stress parameters were estimated to be Φ = 24˚, c – 2,000 psf and Φ = 34˚, c = 1,100 psf for the criterion of peak principal stress difference. The two sets of values for the total stress parameters were obtained because of the high negative pore pressures at which the samples were sheared.

A somewhat inconsistent trend in the values of negative pore pressure generated during shear was apparent. Figures 1 through 2 present the plots for the Mohr envelopes with respect to the effective and total strength parameters both for the 6 foot and 16 foot depth samples.

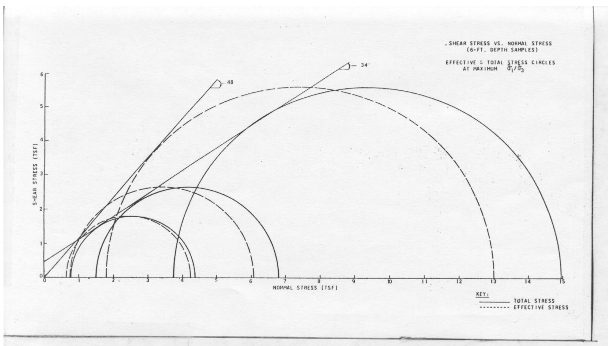

Figure 1. Consolidated Undrained Triaxial Compression Tests on Glacial Till from 6 ft. depths

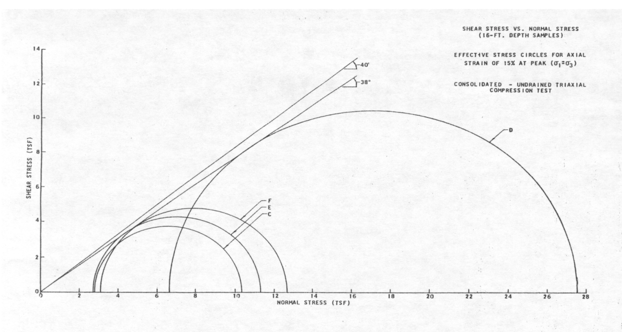

Figure 2. Consolidated Undrained Triaxial Compression Tests on Glacial Till from 16 ft. Depths

STABILITY EVALUATION AND THE CONCEPT OF "FIELD DESIGN CHANGE MANUAL"

Although the effective angles of shearing resistance were found to be as high as 45˚ - 48˚ (Singh, 1976), it was noted that the advantage of unusually densities and friction angles was tempered by the existence of seeps and springs would reduce the shear strength of the soils. Since the till occurs as a relatively thin (approximately 6 ft.) unfrozen layer plastered over bedrock, it was noted that the water pressure in these joints. However, another, but more practical approach recommended by a Task Group (1974) was adopted. According to this approach, construction supervisors or specially trained personnel were instructed to look out for water seeps and springs during construction and to provide drainage facilities as necessary. In a few special cases, a field reconnaissance during dry season to look for geologic and topographic feature which might produce springs during wet weather especially during heavy spring melts, was adopted. Such procedures were incorporated into a "Field Design Change Manual" prepared by the Alyeska Pipeline Company to affect a change in design in the field if soil conditions different from those expected were encountered during construction.

The concept and the use of the Field Design Change Manual was necessary, because, even though more than 2,000 borings were drilled during the design phase of the pipeline, it was expected that areas of unexpected soil conditions would be discovered during construction. To minimize the disruption to construction operations and to allow many decisions of a technical nature to be made in the field, the Field Design Change Manual was prepared and was effectively used.

CONCLUSIONS

1. The presence of high water pressure due to the seeps and springs resulting from heavy melt can adversely affect the strength characteristics of glacial till in cold environment.

2. The concept of observational techniques for springs and seeps during construction to provide drainage can provide an effective means for successful design and construction.

REFERENCES

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2. Task Group Report AS-1 (1974), "Slope Stability Parameters Assessments Alignment Sheets," through 138. Aleyska Pipeline Service Company.