Correlation of Thornthwaite Climate Index (TI) with Rainfall and Suction in Houston

Kalaiarasi Vembu and C. Vipulanandan, PhD., P. E.
Center for Innovative Grouting Materials and Technology (CIGMAT)
Department of Civil and Environmental Engineering
University of Houston, Houston, TX 77204-4003
Tel: 713-743-4291: email: kvembu@mail.uh.edu

Abstract: Thornthwaite moisture index (TI) can be used to characterize the cyclic nature of climatic wetting and drying of soils. TI can be used to predict the active zone and suction profiles of the soil. In this study Thornthwaite moisture index for Houston was studied and compared with the annual rainfall and suction measured in the active zone.

1 Introduction

Active zone is the portion of the ground that experiences seasonal changes in moisture content. The depth of active zone is influenced by the soil type, vegetation, water table, drainage and climate. Severe climate changes will force greater suction changes on the soil resulting in heave/shrinkage and cause damage to the structures. McKeen et al. (1990) used the Thornthwaite index to study the edge moisture penetration distance for the mat foundation. The Post-Tensioning Institute's (1996) design procedures for slab-on-grade foundations and design of vertical pavement moisture barriers use the constant suction at depth to predict differential soil movements that influence shear, deflection, and moment magnitudes and the effective barrier depth. Constant soil suction estimates can be correlated to the climate or long-term weather conditions at any given site by using the TI. In this study TI for Houston was compared with the annual rainfall and suction.

2 Objectives

The objective of this study was to investigate the relationship between Thornthwaite Moisture Index (TI) and annual rainfall and suction measured in the active zone.

3 Thornthwaite Index

Thornthwaite characterized the cyclic nature of climatic wetting and drying of soils (Thornthwaite, 1948). It is not possible to characterize the climate based on the precipitation alone and it should be known whether the precipitation is greater or less than the water needed for evaporation and transpiration. Precipitation and evapotranspiration are equally important climatic factors. Thornthwaite (1948) described the climatic cycle by balancing the rainfall, potential evapotranspiration and soil water holding capacity. All computations were based upon monthly rainfall, mean temperature data, an estimate of the water holding capacity of the soil and the site location. Moist climates have positive values of TI and dry climates have negative values. Figure 1 show the TI based on the weather report from the Houston Hobby Airport. Based on the TI it was found that the year 2003, 2005 and 2008 were drier than the other years.

4 Discussions

Figure 2 shows the variation of TI with the annual rainfall. When the rainfall was more TI had positive value. Hence rainfall is an important criterion for the TI. Figure 3 shows the variation of TI with the suction. Direct measurement of matric suction in a borehole can be obtained by using a tensiometer. The tensiometer was installed in a borehole of 5 ft depth. The suction was monitored for a year.

Reduction in the moisture of content in the active zone results in the high suction pressure and negative Thornthwaite moisture index. From the figs. 2 and 3 it has been found that the rainfall better correlates with Thornthwaite index than the suction pressure. Equation 1 shows the relationship between Thornthwaite index (TI) and the rainfall (RF).

$$TI = 0.317\ RF - 16.5 \quad (\text{with } R = 0.78) \tag{1}$$

Suction will better correlate with the TI if it was measured more than a year covering the cyclic wetting and drying of the soils.

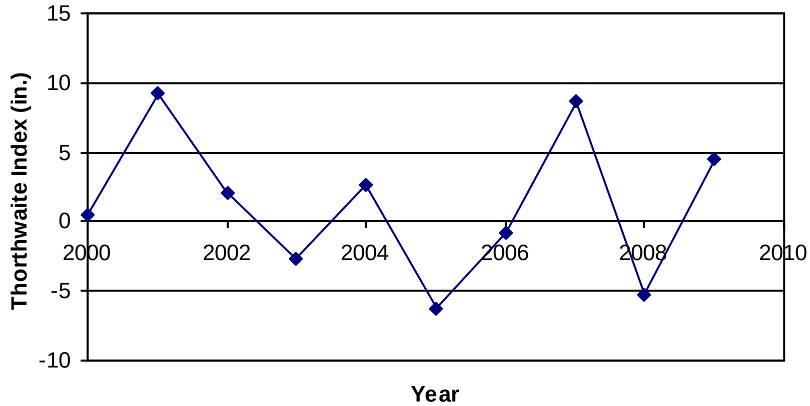

Fig. 1 Thornthwaite Index for Houston (2000-2009)

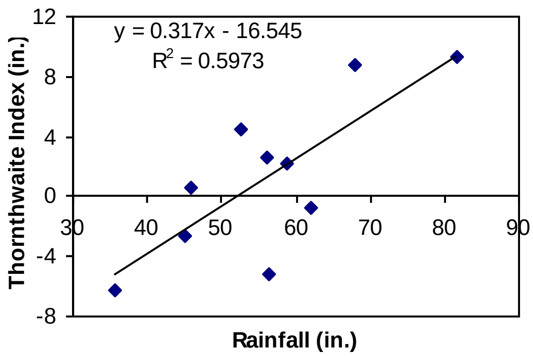

Fig. 2 Correlation of TI with Rainfall

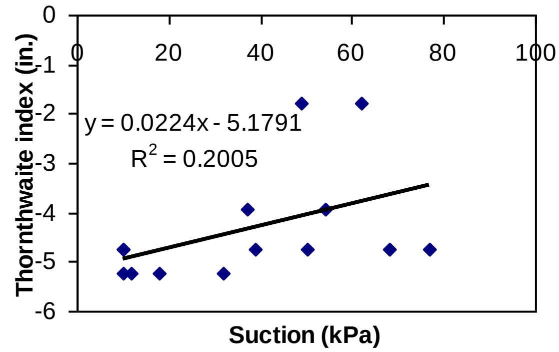

Fig. 3 Correlation of TI with Suction

6 Conclusion

Based on limited data it has been found that the Thornthwaite index was better correlated with the annual rainfall than the suction pressure measured in the active zone. Based on the Thornthwaite index it was found that the year 2003, 2005 and 2008 were drier than the other years.

7 Acknowledgement

This work is supported by the Center for Innovative Grouting Materials and Technology (CIGMAT) with funding from various industries.

8 References

1. Design and Construction of Post-Tensioned Slabs-on-ground. (1980). Post-Tensioning Inst., Phoenix, Ariz.
2. McKeen, R. G., and Johnson, L. D. (1990). "Climate-Controlled Soil Design Parameters for Mat Foundations." Jl.of Geotech. Engrg., ASCE 116(7), 1073-1094.
3. Thornthwaite, C. W. (1948). "An approach toward a rational classification of climate." Geographical Review, 38(1), 54-94.