BEARING CHARACTERISTIC OF FOUNDATION ON CEMENT ADMIXED CLAY LAYER UNDER ELEVATED TEMPERATURE

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ABSTRACT

This paper presents the simulation results of bearing capacity characteristic of foundation on cement admixed clay layer under elevated temperature using the experimental data reported in literature. The simulation results show a decrease in bearing capacity of foundation on cement admixed clay layer with temperature. At higher cement content, the effect of temperature is more influent on the bearing capacity. Furthermore, the safety factor increases with increasing cement content for small value of cement content. With increasing cement content greater than 5%, the safety factor decreases with increasing cement content.

Keywords: cement admixed clay, thermal effect, bearing capacity, safety factor.

INTRODUCTION

Typically a shallow foundation is constructed to support lightweight structure situated on clayey soil layer. The major concern, which a designer have to be careful, are the safety factor against bearing capacity at the end of construction and the long term settlement. Other environmental factors, which are always ignored, are a variation of water content in unsaturated soils with seasonal change and a thermal effect due to facilities generating heat. Typical facilities generating heat to the surrounding soils include underground nuclear waste repositories, buried high-voltage cables and buried hot pipes.

The effect of water content in unsaturated soils due to seasonal change is usually studied in terms of matric suction effect on bearing capacity. Uchaipichat and Man-koksung (2011a) proposed the expression for bearing capacity of foundation on unsaturated soils including suction effect. The experimental investigation on bearing capacity characteristic of foundation on unsaturated soil was performed by Uchaipichat and Man-koksung (2011b). The study shows that the trend of simulation results well agreed with the experimental data.

The thermal effect on soil behaviors has been investigated by several researchers (e.g. Campanella and Mitchell, 1968; Plum and Esrig, 1969; Hueckel and Baldi, 1990; Tanaka, 1995; Graham *et al*., 2001 and Uchaipichat, 2010). Typical results have shown that the pore water pressure increased with an increasing temperature and reduced when the temperature decreased. However, studies of thermal effect on bearing capacity characteristic have been rarely found in literature.

It has also been found for several decades that adding cement improves the strength characteristics of soils, particularly for fine-grained and peat soils (e.g. Horpibulsuk *et al*., 2003; Kalantari and Huat, 2008). For cement admixed soils, an optimum cement content, at which a reduction in strength with increasing temperature is minimize, can be obtained (Uchaipichat, 2010).

Thus, this study is aimed at investigating bearing capacity characteristic of foundation on cement admixed clay layer under elevated temperature. The simulations are performed using the experimental data reported by Uchaipichat (2010). The simulations of bearing capacity and factor of safety are presented and discussed.

BEARING CAPACITY OF FOUNDATION

Several equations for the ultimate bearing capacity of shallow foundation have been proposed with assumption of fully saturated or completely dry conditions (Terzaghi, 1943; Meyerhof, 1963; Hansen, 1968). The general form of ultimate bearing capacity of shallow strip foundation can be expressed as,

$$q_{ult} = cN_c + qN_q + \frac{1}{2}\gamma BN_\gamma \quad (1)$$

in which, q_{ult} is the ultimate bearing capacity, c is the cohesion, q is the surcharge at foundation base, γ is the unit weight of foundation soil, B is the foundation width and N_c, N_q and N_γ are bearing capacity factors related to the internal angle of friction between soil grains.

In case of end of construction on the clay layer, the undrained condition, in which no dissipation of pore water pressure occurs, is assumed. In this case, the value of the internal angle of friction equal to zero and the cohesion (c) become the undrained shear strength (S_u). Thus, $N_c = 5.14$, $N_q = 1$, $N_\gamma = 0$ (Meyerhof, 1963) and Equation (1) becomes,

$$q_{ult} = 5.14S_u + q \quad (2)$$

BEARING CHARACTERISTIC OF FOUNDATION ON CEMENT ADMIXED CLAY LAYER UNDER ELEVATED TEMPERATURE

Uchaipichat (2010) investigated the thermal effect on unconfined compressive strength on cement admixed clay. The results show a variation of unconfined compressive strength with temperature. Table-1 shows the variation of undrained shear strength of cement admixed clay, which is a half of unconfined compressive strength, with temperature. The undrained shear strength increases with increasing cement content but decreases with increasing temperature.

Table-1. Variation of undrained shear strength of cement admixed clay with cement content and temperature.

Cement content, (A_w, %)	Undrained shear strength, S_u (ksc)		
	T = 25°C	T = 40°C	T = 60°C
2	1.90	1.45	1.20
5	3.75	3.05	2.75
10	6.90	5.55	4.75
20	15.30	10.70	7.80

The ultimate bearing capacity of foundation can be calculated using Equation (2). Figure-1 shows the decrease in bearing capacity of foundation on cement admixed clay layer with temperature. At higher cement content, the effect of temperature is more influent on the bearing capacity. Figure-2 shows the variation of bearing capacity with cement content for different temperature values. It is obvious that the increase in bearing capacity with cement content can be obtained at all testing temperatures.

SAFETY FACTOR AGAINST BEARING CAPACITY OF FOUNDATION

To discuss the variation of safety factor against bearing capacity of foundation on cement admixed clay layer with temperature, it is assumed that the safety factor for all cement content at temperature of 25°C is equal to 2. The expression of safety can be written as,

$$FS = \frac{q_{ult}}{q_{allow}} \tag{3}$$

Where, FS is the safety factor and q_{allow} is the allowable bearing capacity. Thus, the values of allowable bearing capacity of foundation on cemented clay layer with various values cement content are shown in Table-3. The variation of safety factor calculated using the expression in Equation (3) with temperature is shown in Figure-3.

Figure-4 shows a variation of safety factor with cement content for temperature values of 40 and 60°C. It can be seen that the safety factor increases with increasing cement content for small value of cement content. With increasing cement content greater than 5%, the safety factor decreases with increasing cement content.

Table-2. Variation of bearing capacity of cement admixed clay with cement content and temperature.

Cement content, (A_w, %)	Ultimate bearing capacity, q_{ult} (ksc)		
	T = 25°C	T = 40°C	T = 60°C
2	9.8	7.5	6.2
5	19.3	15.7	14.1
10	35.5	28.5	24.4
20	78.6	55.0	40.1

Table-3. Allowable bearing capacity of foundation on cemented clay layer with various values cement content.

Cement content (A_w, %)	Allowable bearing capacity (q_{allow}, ksc)
2	4.9
5	9.6
10	17.7
20	39.3

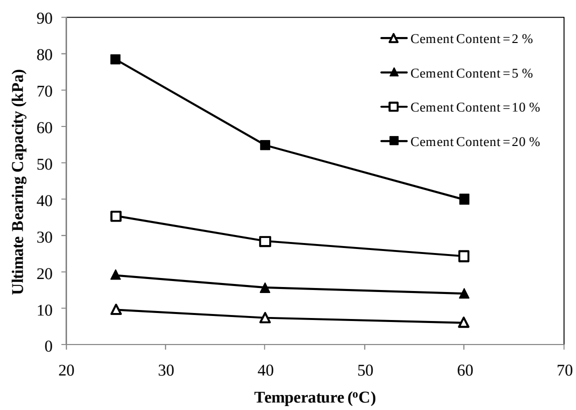

Figure-1. Variation of bearing capacity of foundation on cement admixed clay layer with temperature.

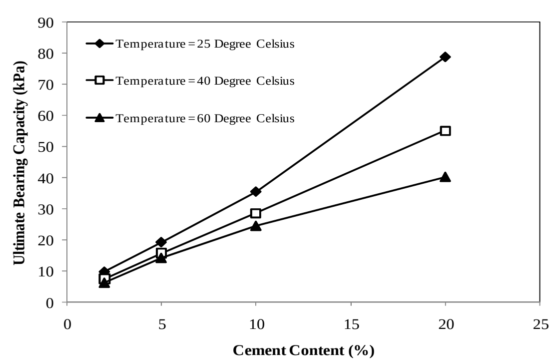

Figure-2. Variation of bearing capacity with cement content and temperature.

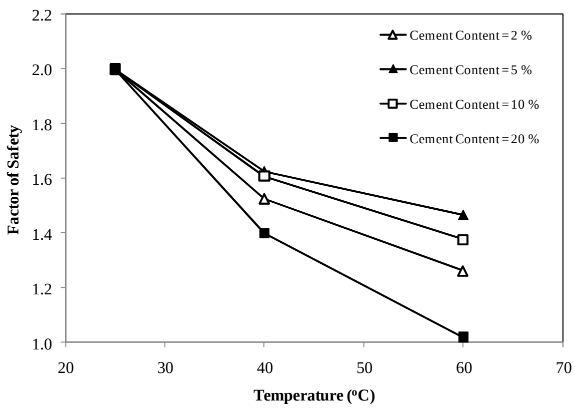

Figure-3. Variation of safety factor against bearing capacity of foundation on cemented clay with temperature.

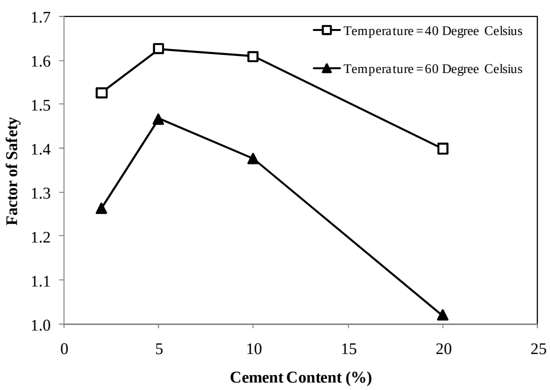

Figure-4. Variation of safety factor with cement content for temperature values of 40 and 60°C

CONCLUSIONS

The bearing capacity characteristic of foundation on cement admixed clay layer under elevated temperature is simulated using the experimental data reported by Uchaipichat (2010). The simulation results show a decrease in bearing capacity of foundation on cement admixed clay layer with temperature. At higher cement content, the effect of temperature is more influent on the bearing capacity. Furthermore, the safety factor increases with increasing cement content for small value of cement content. With increasing cement content greater than 5%, the safety factor decreases with increasing cement content.

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