Energy Function in Interference Between Surface Footings

by

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When a footing placed on the surface of partially saturated soil is loaded the process of footing penetration results in changes in structural arrangement of soil grains as well as porosity and partial expulsion of liquid and gaseous components. Penetration process involves in the conversion of mechanical energy to heat energy, though the operation is affected by densification of the medium. A fraction of energy is also lost due to friction between the footing and the medium.

Katsygin (1968) formualted the following hyperbalic function to govern the law of soil resistance:-

$$p = p_o \tan h \left(\frac{k}{p_o} z \right) \quad \ldots(1)$$

where

$$p_o = \frac{p_1}{\sqrt{(2p_1/p_2)-1}} \quad \ldots(2)$$

and

$$k = \frac{p_o}{H_1} \tan^{-1} \frac{p_1}{p_o} \quad \ldots(3)$$

in which case

p = Stress corresponding to a penetration of, Z.

p_o = Ultimate bearing capacity

p_1 = Stress corresponding to a penetration of H_1

p_2 = Stress corresponding to a penetration of $2H_1$.

Majumdar (1973) using Katsygin's equations formulated energy functions.

Since, work done = Force x translation of the boundaries in the direction of force

$$dw = p\, dv = p\, A\, dz$$

$$= A \left[p_o \tan h \left(\frac{k}{p_o} Z\right) dZ \right] \quad \ldots(4)$$

Integrating the Equation 4, between the limits $Z_1 = 0$ to $Z_2 = Z$

$$\text{Total work done } W = A \left[\frac{p_0^2}{k} \log_e \ \text{Cos}\, h \left(\frac{k}{p_o} Z\right) \right] \quad \ldots(5)$$

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Therefore penetration energy required per unit area of penetration

$$E_n = \frac{W}{A} = \frac{p_0^2}{K} \log_e \text{Cos h} \left(\frac{k}{p_h}\right) Z) \qquad ...(6)$$

In order to study the effect of interference between two square surface footings at different spacings, laboratory tests were conducted on partially saturated soil medium with one footing loaded to an intensity of 1.50 kg/cm² and the other loaded to failure. From the load-settlement curves of these tests, the values of p^1, p^2, H^1 and H^2 are found out. Subsequently the values of p_o, k and E_n for different values of footing penetration are computed using the equation 2,3 and 6. The energy requirement ratios (E^n/E_n') for different cases are calculated assuming E_n' to be the energy requirement of as isolated footing experiencing no effect of interference. The following conclusions are drawn from the analyses:-

1. As spacings between the footings are increased, for the same penetration to width ratio (Z/B):
   (a) E_n/E_n' increases for values of $Z/B \leqslant 0.01$
   (b) E_n/E_n' decreases for values of $0.01 < Z/B \leqslant 0.15$ and
   (c) Thereafter, F_n/E_n' remains almost constant.
2. In most of the cases, the absolute values of E_n/E_n' are minimum for spacings 2.75 B to 3.50 B C/C between the footings. This is indicative of the maximum effect of the adjacent footing on the settlement of the footing loaded to failure when the spacing between 2.76 B to 3.50 B C/C.

References

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