

การรับแรงในแนวราบของ เสาเข็มในดินกรุงเทพฯ



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"The Laterally Loaded Piles in Bangkok Clay"

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ABSTRACT

A programme of pile test was carried out at Chulalongkorn University campus, where there is a deep deposit of soft clay, to examine the performance of laterally loaded unrestrained piles. Short rectangular piles of 13 x 35 cm. 3.50 m. long and long piles of 18 cm. square 7 m. long were employed. Maintained load (ML), constant rate of deflection (CRD), quick maintained load and repetitive loading tests were carried out on the piles.

The ultimate lateral resistance has been calculated by Brom's method assuming that failure takes place either when one plastic hinge form along each individual pile or when the lateral resistance of the supporting soil is exceeded along the total length of the laterally loaded pile. Lateral deflections at working loads have been calculated using the theory of subgrade reaction and the theory of elasticity.

The results from the proposed design methods have been compared with test data. Satisfactory agreement has been found between measured and calculated ultimate lateral resistance. The results confirm that the subgrade reaction theory greatly overestimates the lateral deflection of the pile foundation, however good agreement is found between

the measured lateral deflections and the predicted lateral deflections, using a value of Young's modulus of $400 c_u$ in the analysis.

หัวข้อวิทยานิพนธ์ การรับแรงในแนวราบของเสาเข็มในดินกรุงเทพฯ
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บทคัดย่อ



การทดสอบการรับแรงของเสาเข็มในแนวราบได้กระทำในบริเวณ
จุฬาลงกรณ์มหาวิทยาลัย เสาเข็มที่จัดทำทดสอบเป็นเสาเข็มคอนกรีตชนิดที่หัวเข็มสามารถ
เคลื่อนที่โดยอิสระ เสาชนิดสั้นเป็นรูปสี่เหลี่ยมผืนผ้าขนาด 18 x 35 เซนติเมตร
ยาว 3.50 เมตร เสาชนิดยาวเป็นรูปสี่เหลี่ยมจัตุรัส ขนาด 18 x 18 เซนติเมตร
ยาว 7 เมตร วิธีที่ใช้ในการทดสอบมี **maintained load test, constant rate
of deflection test, quick maintained load and repetitive loading
tests.**

การคำนวณหาค่าแรงต้านทานสูงสุดตามแนวราบ (**ultimate lateral
resistance**) ใช้วิธีของบรอมส์ (BROMS) โดยถือว่าเสาเข็มถึงขั้นพิบัติ
เมื่อเกิดจุดหมุนพลาสติก (**plastic hinge**) ขึ้น 1 จุด ในเสาเข็ม หรือเมื่อคิน
ตลอดความยาวของเสาเข็มไม่สามารถรับแรงได้อีก เมื่อแรงยังอยู่ในพิสัยใช้งานระยะ
โก่งตัวในแนวราบของเสาเข็มคำนวณได้จาก **Theory of subgrade reaction**
และทฤษฎีการยืดหยุ่น (**Theory of elasticity**)

จากการเปรียบเทียบผลการทดสอบกับทฤษฎี ปรากฏว่าค่าแรงต้านทาน
สูงสุดตามแนวราบจากการทดลองมีค่าใกล้เคียงกับการคำนวณ

จากการทดลองนี้ยังชี้ให้เห็นอีกว่า **Subgrade reaction theory**
จะให้ค่าระยะโก่งตัวของเสาเข็มเกินกว่าความเป็นจริง แต่อย่างไรก็ดีเมื่อใช้ค่า
โมดูลัสยืดหยุ่น (**Modulus of elasticity**) ของดินเท่ากับ $400 c_u$
ในการคำนวณจะให้ค่าระยะโก่งตัวของเสาเข็มใกล้เคียงกับความเป็นจริง

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LIST OF SYMBOLS

The following symbols have been adopted for use in

this paper:

- $A(x) = e^{-\beta x}(\cos \beta x + \sin \beta x)$
 B = diameter or width of load plate, in cm.
 $B(x) = e^{-\beta x} \sin \beta x$
 $C(x) = e^{-\beta x}(\cos \beta x - \sin \beta x)$
 c_u = cohesion determined from undrained triaxial, direct shear or vane tests, in ksc.
 D = diameter or width of test pile, in cm.
 $D(x) = e^{-\beta x}(\cos \beta x - \sin \beta x)$
 d_o = deflection of load plate, in cm.
 E_p = modulus of elasticity of pile material, in ksc.
 E_s = modulus of elasticity of soil, in ksc.
 E_{50} = secant modulus corresponding to half the ultimate unconfined compressive strength of the soil, in ksc.
 f = distance from 1.5 pile diameters below ground surface to location of maximum bending moment in cm.
 g = distance from location of maximum bending moment to bottom of pile in cm.
 I_p = moment of inertia of pile section, in cm^4 .
 K = kD , in ksc.
 K_o = $k_o B$, in ksc.
 K_{∞} = $k_{\infty} D$, in ksc.
 k = coefficient of subgrade reaction, in kg/cm^3

- k_m = coefficient of lateral subgrade reaction with respect to moment acting at mid-height of short laterally loaded piles, in kg/cm^3
- k_o = coefficient of subgrade reaction of square or circular plates, in kg/cm^3
- k_p = coefficient of lateral subgrade reaction with respect to load acting at mid height of short laterally loaded piles, in kg/cm^3
- k_{∞} = coefficient of lateral subgrade reaction for a long laterally loaded pile, in kg/cm^3
- L = length of embedment, in cm.
- L' = equivalent length of embedment, in cm.
- n_1 = coefficient
- n_2 = coefficient
- M = moment, in kg-cm
- $M_{\text{max}}^{\text{pos}}$ = maximum positive bending moment, in kg-cm
- $M_{\text{max}}^{\text{neg}}$ = maximum negative bending moment, in kg-cm
- M_{yield} = yield or ultimate moment resistance of pile section, in kg-cm
- P = lateral load, in kg.
- P_{ult} = ultimate lateral resistance, in kg.
- Q = soil reaction per unit length of pile, in kg/cm
- q = unit soil reaction, in ksc.
- q_u = unconfined compressive strength, in ksc.
- q_{ult} = ultimate lateral resistance, in ksc.
- U.C. = unconfined compression test

- W_l = liquid limit
- W_n = natural water content
- W_p = plastic limit
- y = lateral deflection, in cm.
- y_o = lateral deflection at ground surface, in cm.
- y_m = lateral deflection at ground surface caused by moment acting at mid-height of short piles, in cm.
- y_p = deflection at ground surface caused by load acting at mid-height of short piles, in cm.
- y_{calc} = calculated lateral deflection at ground surface, in cm.
- y_{test} = measured lateral deflection at ground surface, in cm.
- α = coefficient equal to $n_1 n_2$
- βL = dimensionless length
- M_s = poisson's ratio