BEHAVIORS OF CEMENT-TREATED LATERITE WITH INDUSTRIAL ASH REPLACEMENT FOR CONSTRUCTION OF ROAD STRUCTURE

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Abstract

This research presents a study on strength and deformation characteristics of cement mixed laterite with partial cement replacement by fly ash and rice husk ash. Special attention was paid to the investigation of stiffness of the mixtures under cyclic loading, or the equivalent modulus. The experimental study was done by performing a series of unconventional unconfined compression and cyclic loading tests. All strain values were locally measured by means of a pair of local deformation transducers (LDTs). From tested results, unconfined compressive strength of the mixtures having small cement content (1% for fly ash and 1-2% for rice husk ash replacement) with ash replacement of 10-30%, is close to that of the mixtures without ash replacement. For mixtures with higher cement content (2% or 3%), replacing the cement with ashes of 10-30% results in decrease of value of unconfined compressive strength. The efficiency of fly ash and rice husk ash on Portland cement replacement partially in laterite soil cement was discussed. The equivalent modulus values (E_{eq}) from cyclic loading test were evaluated by performing monotonic loading to considered level stress and sustained loading then applied minute-amplitude cycles of unload and reload. The cyclic loading test results indicate that equivalent values did not decrease with varying fly ash and rice husk ash proportion for cement replacement, except for 30% of fly ash replacement. An empirical equation relating the efficiency factor (k) and mixing proportion proposed a good prediction for ultimate strength and equivalent modulus values.

Keywords: Unconfined Compression Test / Cyclic Loading Test / Fly Ash / Rice Husk Ash / Efficiency Factor / Equivalent Modulus

หัวข้อวิทยานิพนธ์	พฤติกรรมของวัสดุดินลูกรังผสมซีเมนต์ และแทนที่บางส่วนด้วยเถ้าอุตสาหกรรมในงานก่อสร้างชั้นทาง
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บทคัดย่อ

งานวิจัยนี้เป็นการศึกษาพฤติกรรมด้านกำลัง และการเสียรูปของดินลูกรังผสมซีเมนต์ที่มีการแทนที่ด้วยเถ้าลอย และเถ้าแกลบเป็นบางส่วน โดยให้ความสนใจเป็นพิเศษกับค่าสติฟเนสภายใต้การรับแรงแบบวงรอบซึ่งเรียกว่า ค่าโมดูลัสสมมูลย์ งานวิจัยนี้ได้ทำการทดสอบการรับแรงอัดทิศทางเดียว และการทดสอบการให้น้ำหนักแบบวงรอบ ทำการวัดการเสียรูปด้วยการวัดแบบเฉพาะ โดยเครื่องมือวัดการเคลื่อนที่เฉพาะจุด (LDTs) จากผลการทดสอบการรับแรงอัดทิศทางเดียวของวัสดุดินลูกรังผสมซีเมนต์ที่อายุบ่ม 28 วัน เมื่อแทนที่ปูนซีเมนต์ที่ร้อยละ 1 และ 2 ด้วยเถ้าแกลบปริมาณ ร้อยละ 10-30 สามารถให้ค่ากำลังรับแรงอัด ใกล้เคียงกับตัวอย่างที่ไม่แทนที่ด้วยเถ้า และการแทนที่ปูนซีเมนต์ร้อยละ 1 ด้วยเถ้าลอยปริมาณ ร้อยละ 10-30 สามารถให้กำลังรับแรงอัดได้เท่ากับ ตัวอย่างที่ไม่มีการแทนที่ สำหรับปริมาณปูนซีเมนต์ที่สูงขึ้น (2-3%) การแทนที่ด้วยเถ้าทำให้กำลังของวัสดุผสมลดลง การทดสอบได้วิเคราะห์ประสิทธิภาพของเถ้าลอย และเถ้าแกลบในการแทนที่ซีเมนต์ด้วย สำหรับค่าโมดูลัสสมมูลย์หาได้จากการทดสอบการให้น้ำหนักแบบเป็นวงรอบ โดยการให้น้ำหนักต่อเนื่องทิศทางเดียวแทรกด้วยแรงคงค้าง แล้วจึงให้น้ำหนักแบบเป็นวงรอบซึ่งจากผลการทดสอบที่ได้พบว่าการแทนที่ปูนซีเมนต์ด้วยเถ้านั้นไม่ทำให้ค่าโมดูลัสสมมูลย์ลดลงแต่อย่างใด เว้นแต่ในกรณีของการแทนที่ด้วยเถ้าลอยที่ปริมาณร้อยละ 30 เท่านั้น ที่ทำให้มีค่าลดลง จากผลการวิเคราะห์นำไปสู่การเสนอสมการอย่างง่าย โดยอาศัยความสัมพันธ์ของแฟกเตอร์ประสิทธิผลของส่วนผสม ซึ่งมีความแม่นยำในการทำนายค่ากำลังและค่าโมดูลัสสมมูลย์อยู่ในเกณฑ์ดี

คำสำคัญ: การทดสอบการรับแรงอัดทิศทางเดียว / การทดสอบการให้น้ำหนักแบบเป็นวงรอบ / เถ้าลอย / เถ้าแกลบ / แฟกเตอร์ประสิทธิผล / โมดูลัสสมมูลย์

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LIST OF SYMBOLS

a = coefficient depending mainly on curing time
A = dimensionless constants
A_f = percentage of ash in mixture or ash content.
A_w = cement content, %
A^*_w = equivalent cementitious content, %
B = dimensionless constants
C = cement content, %
CL = cyclic loading
C_w = the total clay water content, %
E = modulus of elasticity or Young's modulus
E_{eq} = equivalent Young's modulus
$E_{0.4\sigma}$ = equivalent Young's modulus at 40% ultimate strength
e_{ot} = after curing void ratio
e_s = effective void ratio
e_{st} = total effective void ratio
FA = fly ash
f'_c = compressive strength
G_s = specific gravity
G_{so} = Specific gravity of base clay
G_{st} = the after-curing specific gravity (dimensionless)
k = constant represent a replacing of pozzolanic material to cement
K = coefficient depending mainly on curing time
P = pozzolanic material content, %
q_u = unconfined compressive strength
RHA = rice husk ash
S_u = undrained shear strength
σ_a = axial stress
ε_a = axial strain
t = curing time in day
w/c = the water-cement ratio by weight
γ_t = after-curing unit weight of the treated soil, kN/m^3
γ_w = after-curing unit weight of water, kN/m^3
ψ = constant value