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GEOMECHANICAL ASPECTS AND THEIR APPLICATIONS TO THE DIVERSION TUNNEL STABILITY AT CHIEW LARN DAM SITE, CHANGWAT SURAT THANI

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บทคัดย่อ

การศึกษาเชิงเทคโนโลยีธรณีในบริเวณที่ก่อสร้างเขื่อนเชี่ยวหลาน จังหวัดสุราษฎร์ธานี โดยเฉพาะบริเวณก่อสร้างอุโมงค์ผันน้ำพบว่าบริเวณที่ศึกษาประกอบด้วยหิน graywacke เป็นส่วนใหญ่กับมีหิน subarkosic sandstone ปนอยู่บ้าง คุณสมบัติเชิงธรณีกลศาสตร์ของหินเหล่านี้มีความสัมพันธ์แนบแน่นกับดัชนีของพฤติกรรมของหินบริเวณที่กำลังขุดเจาะอุโมงค์อยู่ คุณสมบัติที่เป็นค่าดัชนีนี้ได้จากการศึกษาและทดสอบ ในลักษณะต่าง ๆ ทั้งด้านศิลาวิทยา การศึกษารอยแตกและลักษณะทางกายภาพและกลศาสตร์ของหิน การศึกษาและทดสอบกระทำทั้งในพื้นที่ก่อสร้าง ในห้องปฏิบัติการประจำบริเวณก่อสร้าง และห้องปฏิบัติการประจำสำนักงาน ค่าคุณสมบัติเหล่านี้บางค่าได้แก่ค่าความหนาแน่นและค่าความแข็งวัดได้จาก Schmidt rebound hammer สามารถจะใช้เป็นตัวประเมินสถานะภาพของมวลหินอย่างหยาบได้ ขณะที่การประเมินสถานภาพอย่างละเอียดได้กระทำโดยใช้วิธีจำแนกหินเชิงวิศวกรรม โดยอาศัยค่าคุณสมบัติดัชนีอื่น ๆ ประกอบกัน นอกจากนั้นค่าคุณสมบัตินี้ยังใช้เพื่อการประเมินความเหมาะสมของหิน graywacke ในฐานะเป็นวัสดุก่อสร้างด้วย ผลสรุปเฉพาะด้านนี้ระบุว่าหินนี้ไม่เหมาะที่จะใช้เป็นหินบดสำหรับการก่อสร้าง

ผลการศึกษาทั้งหมดได้ถูกรวบรวมมาเพื่อการเปรียบเทียบและวิเคราะห์เพื่อประเมินค่าเสถียรภาพของบริเวณอุโมงค์ผันน้ำทั้งในตัวอุโมงค์และบริเวณที่ลาดเอียงที่ปากอุโมงค์ทั้งสอง

ด้าน และบริเวณฐานรากของเขื่อน ผลการเปรียบเทียบระหว่างระบบจำแนกเชิงธรณีกลศาสตร์และระบบ Q เพื่อศึกษาเสถียรภาพภายในตัวอุโมงค์ พบว่าลักษณะของมวลหินส่วนใหญ่อยู่ใน Class II ซึ่งแสดงว่ามีเสถียรภาพดี ขณะที่บางบริเวณมีการแปรปรวนสูงถึง Class V ซึ่งแสดงว่าบริเวณเหล่านั้นมีเสถียรภาพต่ำขณะเดียวกันผลการตรวจสอบการขยายตัวของมวลหินจาก 3 บริเวณในตัวอุโมงค์ ดังกล่าวพบว่าการขยายตัวเป็นไปอย่างปกติ

การศึกษาเสถียรภาพของที่ลาดเอียงบริเวณปากอุโมงค์โดยใช้วิธีตาข่ายมิติและระบบจำแนกเชิงธรณีกลศาสตร์ระบุว่าบางบริเวณมีเสถียรภาพต่ำ โดยอาจจะเกิดการพังทลายได้แบบล้มหรือการเลื่อนแบบระนาบตามรอยแตกที่มีอยู่แล้วในหิน ส่วนการศึกษาเสถียรภาพของฐานรากของเขื่อนโดยใช้ระบบจำแนกเชิงธรณีกลศาสตร์เพื่อสร้างรูปแบบของการเปลี่ยนแปลงพบว่าฐานรากมีเสถียรภาพทั่วไปดีมาก เว้นแต่ในบางบริเวณจำต้องได้รับการปรับปรุงเล็กน้อย

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ABSTRACT

A geotechnological investigation was performed at Chiew Larn damsite in Changwat Surat Thani, southern Thailand, mainly in the diversion tunnel which was being excavated through the graywackes with subordinate subarkosic sandstones. It was found that the geomechanical properties of these rocks had a close relationship with the index behavior of the rock mass here. The index geomechanical properties were obtained from the study and determination on the lithology, some discontinuities, and the physical and mechanical characteristics of the rocks. These were done in-situ, in a field laboratory, and in other fully-equipped laboratories elsewhere. Some of the index properties, especially the density and Schmidt hammer rebound hardness give a rough estimation of the rock mass condition while a more detail estimation was done using an engineering rock classification according to those index geomechanical properties. Besides some properties were used to estimate the

suitability of the graywackes as the alternative construction materials. The latter study indicated a rather negative result for the rocks as the aggregates.

All study results had been compiled for the comparison and analyses for the stability of the diversion tunnel and its portal slopes and of the main dam foundation. A comparison between the Geomechanics Classification system and Q system for the stability determination of the tunnel indicated that most rock masses were in Class II which suggested a stableness while some might vary as far as in Class V which indicated a low stability value. Meanwhile, a normal deformation was recorded in all 3 study zones in the diversion tunnel.

The stereographical methods as well as the Geomechanics Classification system were applied to the stability determination of the slopes of both portals. The study revealed that some slope faces might be unstable. The wedge and planar failures might occur along the existing discontinuities. The Geomechanical Classification system was further applied to the study of the dam foundation stability with a study result showing that the foundation was generally stable though parts of it were needed to be improved.

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ABBREVIATIONS AND SYMBOLS

A	Specimen area, cm^2
ACV	Aggregate crushing value, percent
An	Angularity number
ASTM	American Standard Testing Materials
Bs	British Standard
CSIR	South African Council for Scientific and Industrial Research
CU	Uniformity coefficient
CZ	Curvature coefficient
c_a	Air-dry peak cohesion, MPa
c_s	Saturated peak cohesion, MPa
D	Specimen diameter, cm
E	Young's modulus or modulus of elasticity, MPa
E_L	Laboratory modulus of deformation, GPa
E_M	In-situ modulus of deformation, GPa
E_{ave}	Average modulus of elasticity, MPa
E_{dyn}	Dynamic modulus of elasticity, MPa
E_{sec}	Secant modulus of elasticity, MPa
E_{sta}	Static modulus of elasticity, MPa
E_t	Tangent modulus of elasticity, MPa
EI	Elongation index
EGAT	Electricity Generating Authority of Thailand
ESR	Excavation support ratio
F,P	Applied force at failure

FI	Flakiness index
FM	Fineness modulus
G	Shear modulus of elasticity or modulus of rigidity, MPa
G_a	Air-dry shear modulus of elasticity, MPa
G_d	Oven-dry shear modulus of elasticity, MPa
G_{dyn}	Dynamic shear modulus of elasticity, MPa
G_s	Saturated shear modulus of elasticity, MPa
G_{sta}	Static shear modulus of elasticity, MPa
Ga	Apparent specific gravity
Gwke	Pebbly graywackes to pebbly mudstones
g	Gravitational acceleration, cm/sec^2
h	Specimen height, cm
I_{a_D}	Strength anisotropy index
I_d	Slake durability index, percent
I_s	Point-load strength index, MPa
I_v	Void index, percent
ISRM	International Society for Rock Mechanics
Ja	Joint alteration number
Jn	Joint set number
Jr	Joint roughness number
Jv	Volumetric Joint count
Jw	Joint water reduction
JCS	Joint wall compressive strength
j	Rock mass factor,
K	Bulk modulus, MPa
K_a	Air-dry bulk modulus, MPa

K_d	Oven-dry bulk modulus, MPa
K_{dyn}	Dynamic bulk modulus MPa
K_s	Saturated bulk modulus, MPa
K_{sta}	Static bulk modulus, MPa
k	Horizontal stress, MPa
k_s	Shear stiffness
L	Lame's constant and pulse travel distance, cm
L.A.	Los Angeles abrasion hardness, percent
M_c	Modulus of constrained, MPa
M_r	Modulus of resilience
M_s	Mass of grains, gm
M_t	Modulus of toughness, MPa
M_w	Mass of pore water, gm
n	Porosity, percent
Q	NGI tunnelling quality index
R	Schmidt rebound hardness
R_c	Schmidt rebound hardness correct
RID	Royal Irrigation Department
RMR	Rock mass rating
RQD	Rock quality designation, percent
RSR	Rock structure rating
r	Correlation coefficient
S	Sphericity
Sark	Subarkosic sandstones
Sr	Water absorption, percent
S.D.	Standard deviation
S.G.	Gross apparent specific gravity

SRF	Stress reduction factor
t	Specimen thickness, cm
t_p	P-wave travel distance time, minute
t_s	S-wave travel distance time, minute
U.F.	Uniformity factor
V	Bulk sample volume, cm^3
V_p	P-wave velocity, m/sec
V_s	S-wave velocity, m/sec
v	Void ratio
W,w	Water content, percent
W_d	Dried weight, gm
W_i	Initial weight, gm
Y	Stiffness modulus, MPa
Z	Depth, m
γ_b	Bulk unit weight, $gm/cm^2.sec^2$
ρ	Density, gm/cm^3
ρ_a	Air-dry density, gm/cm^3
ρ_b	Bulk density, gm/cm^3
ρ_d	Oven-dry density, gm/cm^2
ρ_{sat}	Saturated density, gm/cm^3
$\surd$	Poisson's ratio
$\surd_a$	Air-dry Poisson's ratio
$\surd d$	Oven-dry Poisson's ratio
$\surd dyn$	Dynamic Poisson's ratio
$\surd_s$	Saturated Poisson's ratio
$\surd sta$	Static Poisson's ratio
σ_1	Major principal stress, MPa

σ_3	Minor principal stress, MPa
σ_c	Uniaxial compressive stress, MPa
σ_n	Normal compressive stress, MPa
σ_t	Tensile strength, MPa
σ_u	Ultimate uniaxial compressive strength, MPa
σ_v	Vertical stress, MPa
ξ	Strain
ξ_a	Longitudinal or axial strain
ξ_l	Lateral or circumferential strain
ξ_v	Volumetric strain
ϕ	Internal friction angle, degree
ϕ_p	Peak internal friction angle, degree
ϕ_r	Residual internal friction angle, degree
τ	Shear strength, MPa
τ_p	Peak shear strength, MPa
τ_r	Residual shear strength, MPa
λ	Lame's constant