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NUMERICAL ANALYSIS OF TBM TUNNEL BEHAVIOUR AND SUPPORT UNDER HIGH STRESS ROCK MASSES IN PAHANG-SELANGOR RAW WATER TRANSFER TUNNEL

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by

HEYAM HUSSEIN SHAALAN

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LIST OF ABBREVIATIONS

TBM	Tunnel boring machine
CSFG	Cohesion-Softening Friction-Hardening
SFRS	Steel fibre reinforced shotcrete
2D	Two dimensional
3D	Three dimensional
WSM	The World Stress Map
Di	Damage index
URL	Underground research laboratory
SF	Safety factor
SWFS	Cohesion Weakening and Frictional Strengthening
UCS	Uniaxial compressive strength
HME	Hypothetical Modulus of Elasticity
ACI	American concrete institute
NATM	New Austrian tunnelling method
RQD	Rock Quality Designation
JH	Japan Highway Public Corporation
SCC	Self compacting concrete
J1, J2 and J3	Early shotcrete strength classes
GSI	Geological Strength Index

LIST OF SYMBOLS

m, s	Hoek-Brown parameters
m_r	Residual friction
s_r	Residual cohesion
σ_v	Vertical stress
σ_{h1}	Maximum horizontal stress
σ_{h2}	Minimum horizontal stress
σ_1	Major principal stress
σ_2	Medium principal stress
σ_3	Minimum principal stress
H	Tunnel depth
γ	Unit weight
k_0	Coefficient of lateral stress
σ_1'	Maximum effective stresses
σ_3'	Minimum effective stresses at failure
σ_{ci}	Uniaxial compressive strength of the intact rock
m_b	Material constant

m_i	Material constant for the intact rock
D	Degree of disturbance
c	Cohesive strength
$\emptyset$	Angle of friction
τ	Shear strength
σ_n'	Normal stress
σ_t	Rock tensile strength
σ_{max}	Maximum tangential stress
ε	Total strain
ε^e	Elastic strain
ε^p	Plastic strain
ε^{cr}	Creep strain
ε^{shr}	Shrinkage strain
F_C	Mohr-Coulomb yield surface
F_t	Rankine yield surface in the tensile zone
f_{cy}	Uniaxial compressive yield stress
f_t	Tensile strength yield stress
H_C	Normalised strain hardening/softening parameter
ε_{cp}^p	Plastic peak strain in uniaxial compression