

THE EFFECT OF THE ROCKMASS PROPERTIES AND
GROUNDWATER INFLOW RELATED TO PERFORMANCE
OF TUNNEL BORING MACHINE (TBM)
AT PAHANG SELANGOR RAW WATER TRANSFER
TUNNEL PROJECT (PSRWT)

by

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TABLE OF CONTENTS

Acknowledgement	ii
Table of Contents	v
List of Table	x
List of Figure	xii
List of Symbols	xix
List of Abbreviations	xxi
Abstrak	xxii
Abstract	xxiv

CHAPTER 1 - INTRODUCTION

1.1	Problem Statement	1
1.2	Site Selection	7
	1.2.1 Study Area	7
	1.2.2 Project Involved	8
1.3	Objective of Research	16
1.4	Research Approach	17
1.5	Thesis Outline	19

CHAPTER 2 - LITERATURE REVIEW

2.1	Introduction	21
2.2	Numerical Analyses	22
	2.2.1 Joint Behaviour	23
	2.2.2 Rockmass Properties and Geomechanical Classification	23

2.2.3	High localised water inflow and mechanical TBM performance	24
2.3	Correlations of Parameters	27
2.3.1	Correlation between Geological Condition, Hydrogeological Impact and Tunnel Boring Machine Performance	27
2.4	Additional Literature Review	30
2.4.1	Method for excavation involved in PSRWT tunnel project	31
2.4.2	Tunnel Boring Machine	33

CHAPTER 3 - METHODOLOGY

3.1	Introduction	41
3.1.1	Flowchart of Work	41
3.2	Field Data Collection	44
3.2.1	Geological Mapping	44
3.3	Mechanical Data Collection	55
3.3.1	TBM Performance Parameters	55
3.3.2	Parameters Influence the TBM Performance	56
3.3.3	Boring Energy (BE)	57
3.4	Analysis of Joint Orientations	59
3.4.1	Stereographical Projection	59
3.4.2	Computer Software Program Involved	59
3.4.3	Advantage and Disadvantage of Software	60
3.4.4	Streonet analysis by DIPS	61
3.4.5	Rosette Plot by DIPS	63
3.5	Samples Collection	65

3.6	P-Wave Test	68
3.6.1	Scope of the test	69
3.6.2	Advantage & Disadvantage of P-Wave Method	69
3.6.3	Apparatus	69
3.6.4	Test procedure	70
3.6.5	Calculation	73
3.7	Brazilian Test	73
3.7.1	Scope of test	73
3.7.2	Apparatus	73
3.7.3	Procedure	74
3.7.4	Calculation	75
3.8	Uniaxial Compressional Strength Test (UCS)	76
3.8.1	Scope of test	76
3.8.2	Apparatus	76
3.8.3	Procedure	76
3.8.4	Calculation	77
3.9	Triaxial Compression	78
3.9.1	Scope of test	78
3.9.2	Apparatus	79
3.9.3	Procedure	79
3.9.4	Calculation	81
3.10	Finite Element Method Analysis	83
3.10.1	Introduction	83
3.10.2	Computer Software Program Involved	83
3.10.3	Advantage and Disadvantage of Software	84

3.10.4	Procedure	86
3.11	Mineralogical Analyses	91
3.11.1	Apparatus	92
3.11.2	Procedure	93
CHAPTER 4 - GEOLOGY OF THE STUDY AREA		
4.1	Introduction	95
4.1.1	Regional Geology and Tectonic Setting of PSRWT Tunnel Project	95
4.2	Site Selection	102
4.2.1	Geology of TBM-1	102
4.2.2	Engineering Geological Properties	103
4.2.3	Type of Rock & Mineral Content	107
4.2.4	Groundwater	108
CHAPTER 5 - RESULTS AND DISCUSSION		
5.1	Introduction	109
5.2	Field Data Analysis	110
5.2.1	Geological Mapping	110
5.3	Analysis of Joint Pattern and Rosette Diagram	116
5.4	Mechanical Tests	119
5.5	P-Wave Test	119
5.5.1	Result	120
5.6	Uniaxial Compressional Strength Test (UCS)	121
5.6.1	UCS Test in Karak, Pahang, Malaysia (Dry Sample Only)	121

5.6.2	Result UCS Test in Karak, Pahang, Malaysia (UCS Karak Lab)	121
5.6.3	UCS Test in Hokkaido University (HU)	126
5.7	Brazilian Tensile Strength Test (BTS)	130
5.8	Triaxial Compression Test	132
5.8.1	Determination of Friction Angle and Cohesion	132
5.9	Petrography Analysis	137
5.10	Tunnel Analysis with Finite Element Method (FEM)	142
5.10.1	Introduction	142
5.10.2	Tunnel analysis	142
5.10.3	Stress Distribution	148
5.10.4	Factor of Safety (FOS) with FEM by 2D- σ software	150
5.11	TBM Performance	152
5.11.1	Introduction	152
5.11.2	Relationship between TBM Performance Analysis with Water Inflow and Rockmass Properties	155
5.12	The Correlation between Joint Behaviour, Groundwater Inflow And TBM Performance	158
5.13	Tunnel Analysis & TBM Performance	163
CHAPTER 6 - CONCLUSION AND RECOMMENDATION		
6.1	Conclusion	164
6.2	Recommendation	167
REFERENCES		169

LIST OF TABLES

		Page
Table 3.1	Boring Energy (BE) value is influenced by the rockmass and water inflow in TBM-1.	58
Table 4.1	Geological succession at the tunnel area	99
Table. 5.1	Summary of geological map from TD 2000 m until 4000 m	111
Table 5.2	P-wave result for 3 blocks of granite	120
Table 5.3	The value of reaction with number of rebound at 3 sides (down side, side and upside of the tunnel wall and graph of correlation rebound value to compressive strength for Schmidt hammer	123
Table 5.4	Relationship between jointed rock with high groundwater inflows and UCS value	124
Table 5.5	UCS result for dry and wet specimens	127
Table 5.6	Relationship between rock with groundwater inflows and UCS (for Dry and Wet Conditions)	128
Table 5.7	Results of dry and wet specimens	130
Table 5.8	Relationship between high groundwater inflow and BTS Values (for Dry and Wet Conditions)	131
Table 5.9	The triaxial test value with installed confining pressure	132

Table 5.10	Data use for determination of friction angle and cohesion	133
Table 5.11	Input parameters for modelling of tunnel analysis with 2D- σ	137
Table 5.12	Maximum Principle Stress and Minimum Principle Stress	151
Table 5.13	Details of the TBM operations in TBM-1 between TD 3119 until 3278 m, where high localized water inflow was recorded and collapse occurred.	153
Table 5.14	General dataset for the TBM parameter analysis correlated with rockmas properties	155
Table 5.15	The relationship between jointing system, UCS Value, BTS Value and TBM Performance (Boring Energy)	161

LIST OF FIGURES

		Page
Figure 1.1	Causes of tunnel collapses shows that bad ground conditions possessed the highest percentage (after Seidenfuss 2006).	2
Figure 1.2	Overview tunnel covered by plastic sheet at (Location: TD 3300, TBM-1,Karak)	4
Figure 1.3	Water droplets are running at constant rate for few days during the steel rib & steel lagging installation has distorting the tunnel progress. (Location: TD 3376.6, TBM-1,Karak)	4
Figure 1.4	The heavy water flow (right crown) at average rate of 3.5 ton per minute. (Location: TD 3376.6, TBM-1, Karak)	5
Figure 1.5	Performance of TBM has shown sudden dropdown due to the high groundwater inflow occurrences.	6
Figure 1.6	The location map of the study area in conjunction with PSRWT tunnel project with adjacent reservoirs and rivers	10
Figure 1.7	Illustration of the study area in conjunction with PSRWT Tunnel Project (After PSRWT Report,2000)	11
Figure 1.8	Study area integrates with schematic of proposed Pahang – Selangor Raw Water Transfer Water Tunnel (PSRWT) project and its distribution works, dam and intakes. (After PSRWT Report, 2000)	12

Figure 1.9	The cross section of PSRWT tunnel project from Karak to Langat crossing the Titiwangsa Main Range Granite body. (After PSRWT Report, 2000). (Arrow shows the study area)	13
Figure 1.10	TBM machine on its turning to start the excavation activity(From NATM-3 to TBM-1)	15
Figure 1.11	Sequential flowchart throughout this study	17
Figure 2.1	TBM machine on its turning to start the excavation activity (From NATM-3 to TBM-1)	32
Figure 2.2	Tunnel boring machine (after Kawasaki Precision Machinery Ltd., 2007)	32
Figure 2.3	Diagram of tunnelling shield used to construct the Thames tunnel in 1825. (Modified after IMIA Conference Istanbul, 2009)	34
Figure 2.4	Picture of railway tunnel (Underground Tunnel, London)	35
Figure 2.5	Some TBM projects with their recorded average of size with advance rates. (Modified Dean Brox Consulting, 2013)	39
Figure 3.1	Flowchart shows the relationships between all parameters (geological structures, mineralogical analysis, rockmass properties and mechanical characteristics of the rockmass)	42
Figure 3.2 (a)	One of the monitoring process whereby the conductivity, pH and temperature of the localised water seepage (with constant groundwater inflow at the open fracture) for record purpose.	45

Figure 3.2 (b)	Before the TBM starts to operate; the mechanical and electrical maintenance will be carried out. Picture shows the geologist was investigating the disc cutter prior the excavation process.	46
Figure 3.2 (c)	The geologist was taking pictures of wet joints during the hydrogeological mapping exercise.	46
Figure 3.3	Each of these 3 main tables for comparing Japanese Highway System (JHS) and other foreign rock classification (RMR and Q Value).	48
Figure 3.4	The empirical data of total points of observation on tunnel face (rock grades) and support type based on JHS.	48
Figure 3.5	Geological map sheet that mapped every sub section of 10 meter.	51
Figure 3.6	The wall of tunnel is described by few important geological parameters.	52
Figure 3.7	The wall of tunnel is described by few important geological parameters; continuities, joints pattern (orientation), existence of water seepage, rock types, physical rock properties and weathering condition (grade and colour).	54
Figure 3.8	The main parameters for stereonet data ,which are strike (orient 1) and dip (orient 2) data are stored while other additional information function as an option for recording and labelling stage such as traverse, spacing, rock type, surface or seepage.	62
Figure 3.9	Diagram of stereographical projection contours.	63

Figure 3.10	A sample of rosette dialogue and plot.	64
Figure 3.11	Samples are collected at tunnel, TBM-1 site.	66
Figure 3.12	Bulk samples are collected and labelled at tunnel distance (TD) 3020 m at TBM-1.	67
Figure 3.13	(a) Bulk samples are cut into block samples	67
	(b) Block samples of 12 cm x 12 cm x 12 cm are labelled before coring with respect to its location, tunnel distance, TD.	67
Figure 3.14	The procedures for sampling including all the processes above. Weighing, cutting, lapping, measure and premeasure to assure the rock samples quality before undergo destructive testing.	71
Figure 3.15	The transducer is fixed with the soluble gel, which helps to transfer the high frequency sound waves to the rock	72
Figure 3.16	Ultrasonic P-wave tester shows a travel time graph until the graph shows a significant drop trending. P-wave velocity measures the travel speed of longitudinal (primary) wave in the material. The velocity measurements provide correlation to physical properties in terms of compaction degree of the material.	72
Figure 3.17	To avoid external pressure, the specimen needs to be sealed or jacket-ed.	80
Figure 3.18	Boundary of tunnel and cross section of TBM	87
Figure 3.19	Original view before proceeding calculation	88
Figure.3.20	Deformation after proceeding calculation	88

Figure 3.21	Example of normal stress distribution in x-direction, σ_x (Pa)	89
Figure 3.22	Example of normal stress distribution in y-direction, σ_y (Pa)	89
Figure 3.23	Example of shear stress distribution, σ_{xy} (Pa)	90
Figure 3.24	Example of displacement in x-direction, U_x (mm)	90
Figure 3.25	Example of displacement in y-direction, U_y (mm)	91
Figure 3.26	Steps in thin section preparation	94
Figure 4.1	The geological map of the study area.	98
Figure 4.2	Geological cross section of PSRWT tunnel project	101
Figure 5.1	Schematic diagram of fault zone with lineament line, location of joints sets and local water inflow through of the study area. (Modified after SNUIJV, 2012). (Without scale)	114
Figure 5.2	Stereographical projection and rosette diagram, an equal area lower hemisphere plot of great circles representing the average dip and dip directions of two discontinuity sets in a rockmass.	117
Figure 5.3	Relationship between Uniaxial Compressive Strength (UCS) test values (MPa) with high amount of groundwater inflow from TD 2000 m – 4000 m	125
Figure 5.4	High groundwater TBM-1: CH. 9939 (TD 3118 m) until CH. 10019 (TD 3198 m)	129

Figure 5.5	Try and error to find the best relationship $R^2 \approx 1$, between all specimens. From the graph of sample block C which produce $R=1$ we obtain:	135
Figure 5.6	Image of thin section TD 2350 m	138
Figure 5.7	Image of thin section TD 2750 m	139
Figure 5.8	Image of thin section TD 3175 m	140
Figure 5.9	Image of thin section TD 3350 m	141
Figure 5.10	Image of FEM analysis	143
Figure 5.11	Image of FEM analysis	143
Figure 5.12	Image of FEM analysis	144
Figure 5.13	Image of FEM analysis	144
Figure 5.14	Image of FEM analysis	145
Figure 5.15	Image of FEM analysis	146
Figure 5.16	Image of FEM analysis	147
Figure 5.17	Image of FEM analysis	148
Figure 5.18	Image of FEM analysis	149
Figure 5.19	Image of FEM analysis	149
Figure 5.20	Image of FEM analysis	150

Figure 5.21	Boring time cycle details with respect to international norms	153
Figure 5.22	The relationship between all parameters to Boring Energy	157
Figure 5.23	Summary all the correlations factors including between jointing system, UCS Value , BTS Value and TBM Performance (Boring Energy) of the study area throughout 2000m in TBM-1	162

LIST OF SYMBOLS

C	Cohesion
d	Distance
D	Specimen diameter
E	Young's Modulus
L	Length of the specimen
P	Maximum load at failure
p,q,r	Invariants
R	Radius
t_s	Travel time
V_p	Velocity of P-wave
ν	Poisson's Ratio
σ	Horizontal stress
β	Angle between the normal to the fracture plane and the horizontal plane
φ	Friction angle of the fracture
σ_c	Uniaxial compressive strength of rock
$\sigma_{1,f}$	Major principle stress at failure
$\sigma_{a,f}$	Applied failure stress
$\sigma_{d,w}$	Pressure resulting from dead weight of top disk and loading ram
sv	Overburden Load
σ_x	Normal stress distribution in x-direction
σ_y	Normal stress distribution in y-direction
σ_{xy}	Shear stress distribution

$\sigma_{d,w}$	Pressure resulting from dead weight of top disk and loading ram (kPa)
$\hat{\alpha}$	Direction of rock blocks

LIST OF ABBREVIATION

AR	Advancing Rate
ASTM	American Society for Testing and Materials
BE	Boring Energy
BTS	Brazillian Tensile Strength Test
Ch.	Chainage
FEM	Finite Element Method
IMIA	International Association of Engineering Insurers (IMIA)
ISRM	International Society for Rock Mechanics
JHS	Japanese Highway System
Jn	Joint set number
Jr	Joint roughness number
Jw	Joint water reduction factor
L-x	Lineament
MGT	Mesin Gerekan Terowong
PR	Penetration rate
RMR	Rock mass rating
SRF	Stress reduction factor
TBM	Tunnel boring machine
SRTM	Shaded relief topographical map
SHR	Schmidt hammer rebound
TD	Tunnel distance
UCS	Uniaxial Compressional Strength Test

**KESAN DARI CIRI-CIRI JASAD BATUAN DAN PERGERAKAN AIR
BAWAH TANAH TERHADAP PRESTASI MESIN GEREKAN TEROWONG
(MGT) BAGI PROJEK PENYALURAN AIR MENTAH
PAHANG SELANGOR (PPAMPS)**

ABSTRAK

Pergerakan air bawah tanah ke dalam terowong boleh mengakibatkan bahaya dan merupakan faktor penting yang mempengaruhi kemajuan prestasi gerakan terowong. Di dalam kajian ini, sistem kekar lokal dianalisis bagi menghubungkan pergerakan air bawah tanah dan orientasi kekar di sepanjang 2000 meter tempat kajian TBM-1, Karak sepanjang pembinaan Projek Penyaluran Air Mentah Pahang – Selangor (PPAMPS). Geologi kawasan terowong adalah terdiri daripada batuan granit Main Range dan bersambungan dengan batuan meta-sedimen daripada Formasi Karak. Secara strukturnya, TBM-1 didominasi oleh arah Utara- Selatan, Utara Barat - Tenggara dan Timur Laut-Tenggara. Sesar yang memotong batuan granit Main Range menyebabkan banyak kekar terhasil di daerah Karak. Lokasi yang berpotensi dengan kemasukan air bawah tanah yang banyak adalah terbahagi kepada tiga; iaitu set kekar yang selari dengan garisan lineamen utama, iaitu 90 darjah dengan arah pandu terowong, 45 darjah dengan garisan lineamen atau kedua-dua sistem linemen dan membelah lompong dan membentuk zon poket air. Sekurang-kurangnya kesemua set garisan lineamen topografik berkait dengan zon sesar-air. Analisis unjuran stereografik dan plot Rosette mendapati bahawa orientasi kekar didominasi oleh 3 tren silang-potong antara satu sama lain. Kekar tersebut adalah terdiri daripada ; tren Kuala Lumpur – Bukit Tinggi, tren Utara-Selatan and tren Tenggara-Barat

Daya, yang berkait dengan Barat Laut-Tenggara Bukit Tinggi dan Zon Sesar Kuala Lumpur, sesar Utara-Selatan dan sesar Tenggara-Barat Daya. Keputusan dari ujian mekanikal seperti Ujian Kekuatan Mampatan Sepaksi, Kekuatan Tensi Brazil dan Kekuatan Mampatan Tiga Paksi menunjukkan bahawa jasad batuan menjadi lemah dengan nilai basah adalah hampir separuh daripada nilai kering. Melalui ujian kaedah finit elemen yang dilakukan dengan menggunakan parameter daripada ujian mekanikal mendapati bahawa dengan kehadiran air bawah tanah dan kualiti jasad batuan yang rendah boleh mengakibatkan berlakunya deformasi pada terowong.

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ABSTRACT

Groundwater inflow into tunnels can constitute a potential hazard and an important factor influencing the performance of tunnel excavation. In this research, the results on analyses of localised jointing system are presented to study the link of groundwater inflow and the joint orientations along the 2000 meters of TBM-1 site, Karak in conjunction to the construction of Pahang Selangor Raw Water Transfer Tunnel project (PSRWT). The geology along the tunnel route is predominantly the Main Range granite batholith with a lesser extent of meta-sedimentary rocks of the Karak Formation. Structurally, TBM-1 is dominated by joints orientated at N-S, NW-SE and NE-SW direction. Faults that cross-cut the intrusive Main Range Granite rocks trending faults formed the most prominent structures in the vicinity of the Karak. Potential leakage places are identified of three main types of joints orientations; the most permeable place is parallel along the main lineament orientation, followed by perpendicular to 90 degrees to the tunnel drive direction, 45 degrees to the lineament line or combinations of both joints and crossing some of voids which creating pocket water zones. At least three sets of prominent topographic lineaments correspond to fault-zones permeability related. Based on the stereographical projection and rosette diagram analysis, the dominant orientations of joints seem to have occurred at the intersection of 3 cross-cutting trends. They are the