REFERENCES

ASTM "Standard and Relatives to Cement, Lime and Gypsum." Annual Book of ASTM Standard, Part 9, American Society for Testing and Materials, 1971.

ASTM "Standards and Tentatives Relating to Concrete and Mineral Aggregates." Annual Book of ASTM Standards, Part 10, American Society for Testing and Materials, 1971.

Attewell, P.B. and Farmer, I.W. in Principles of Engineering Geology P. 1045. John Wiley & Sons, Inc., 1976.

Aufmuth, R.E. "A Systematic Determination of Engineering Criteria for Rock." Technical Menuscript M 79, Construction Engineering Research Laboratory, Illinois, 1974.

Barton, A.N. "Classification of Rocks" Int. J. Rock Mech. Min. Sci. 2 (1965): 105.

Barton, N. "Recent Experiences with the Q-System of Tunnel Support Desing" in Symposium on Exploration for Rock Engineering (Bieniawski, Z.T. ed.) pp. 107-115., Cape Town A.A. Balkema, Rotterdam, 1976.

Barton, N., Lien, R. and Lunde, J. "Engineering Classification of Rock Masses for the Design of Tunnel Support" Rock Mechanics 6 (1974): 189236.

Belikov, R.P., Zalesskii, B.V., Roxanov, Yu.A., Sanina, E.A. and Timchenlo, I.P. Methods of Studying the Physicomechanical Properties of Rocks. in Physical and Mechanical Properties of Rocks (Zalesskii, B.V. ed.) pp. 1-58, Israel Program for Scientific Translation, Jeusalem, 1967.

Bell, F.G. in Engineering Properties of Soils and Rocks, 2d ed., p. 149, Betterworth & Co. (Publishers) Ltd., London, 1983.

Bergh-Christensen, J. and Selmer-Olsen, R. "On the Resistance to Blasting in Tunnels." Proc. 2d Cong. Int. Soc. Rock Mech. paper 5-7, Vol 3, Belgrade, 1970.

Bieniawski, Z.T. "Estimating the Strength of Rock Materials" J. South Afr. Inst. Min. Metal. 74(8), (1974): 312-320.

_____. "Geomechanics Classification of Rock Masses and Its Application in Tunneling" in 3rd Proceeding of the International Congress on Rock Mechanics (ISRM) pp. 27-32. IIA, Denver, 1974.

_____. "Case Studies; Prediction of Rock Mass Behaviour by the Geomechanics Classification." in Second Australia-New Zealand Conference on Geomechanics pp. 36-41. Vol. 1, The Institute of Engineers, Brishane, Australia, 1975.

_____. "The Point-Load Test in Geotechnical Practice" Engineering Geology 9(1975): 1-11.

_____. "Rock Mass Classifications in Rock Engineering" in Symposium on Exploration for Rock Engineering (Bieniawski, Z.T. ed.) pp. 96-106., Cape Town A.A. Balkema, Rotterdam, 1976.

_____. "Determination Rock Mass Deformability; Experience from from Case Histories." Int. J. Rock Mech. Min. Sci. 15(1978): 237-247

_____. "The Geomechanics Classification in Rock Engineering Applications." in Proc. 4th Cong. Int. Soc. Rock Mech. pp. 41-48, Vol. 2, Balkana, Rotterdam, 1979.

_____. "Tunnel Design by Rock Mass Classifications." Technical Report GL-79-19, Vicksburgh Miss., U.S. Army Waterways Experimental Station, U.S.A., 1979

_____. "Rock Classifications; State of the Art and Prospects for Standardization." Transportation Research Record 780-784(1980): 2-9.

Bieniawski, Z.T. and Maschek, R.K. "Monitoring the Behaviour of Rock Tunnels During Construction" Trans. S.Afr. Int. Civ. Eng. 17(10), (1975): 255-264.

Bieniawski, Z.T. and Orr, C.M. "Rapid Site Appraisal for Dam Foundations by the Geomechanics Classification" in 12th Proceeding of Inter national Congress of Large Dams pp. 483-501, Mexico City, 1976.

Bonner, B.P. and Schock, R.N. Seismic Wave Velocity. in Physical Properties of Rock and Minerals, (Touloukian, Y.S. and Ho, C.Y. eds.) Vo. II-2 pp. 221-256. McGraw-Hill Book Company, U.S.A., 1981.

Broch, E. and Franklin, J.A. "The Point-Load Strength Test." Int. J. Rock Mech. Min. Sci. 9(6), (1972): 669-697.

Brook, N. "A Method of Overcoming both Shape and Size Effects in Point-Loas Testing." Proc. Conf. Rock Engineering pp. 53-70. British Geotech. Soc., London, 1977.

Brook, N. Size Correction for Point-Load Testing." J. Rock Mech. Min. Sci. 17(1980): 231-235.

BS "British Standard Methods for Sampling and Testing of Mineral Aggregates, Sands and Fillers." British Standard 812, UDC 625.07-620.1, British Standard Institution, 1967.

Ruxton, B.P. and Berry, L. "Weathering of Granite and Associated Erosional Features in Hong Kong." Bull. Geol. Soc. America Vol. 68 pp. 1263-1292, 1957.

Caterpillar Tractor Co. in Handbook of Ripping, A Guide to Greater Profits, 3d ed., Peoria, Illinois, 1966.

Chappell, B.A. and Maurice, R. "Classification of Rock Mass Related to Foundations." in Proc. Int. Conf. Rock Mech. pp. 29-36, Sydney, 1980.

Coates, D.F. "Classification of Rocks for Rock Mechanics" Int. J. Rock Mech. Min. Sci. 1(3), (1964): 421-429.

Coated, D.F. and Parson, R.C. "Experimental Criteria for classification of Rock Substances." Int. J. Rock Mech. Min. Sci. 3(1966): 181-189.

Coon, R.F. and Merritt, A.H., "Predicting In Sith Modulus of Deformation Using Rock Quality Indexes." in Determination of the In Situ Modulus of Deformation of Rock. ASTM STP 477 pp. 154-173. American Society for Testing and Materials, 1970.

Cording, E.J. and Mahar, J.W. "Index Properties and Observations for Design of Chambers in Rock." Engineering Geology 12(2), (1978): 113-142.

D'Andrea, D.V., Fisher, R.L. and Fogelson, D.E. "Prediction of Compressive Strength of Rock from Other Rock Properties." Report of Investigations 6702, U.S. Bureau of Mines, 1965.

Dearman, W.E. "Weathering Classification in the Characterization of Rock." Bull. Int. Assoc. Eng. Geol. No. 13 pp. 123-127 Germany, 1976.

Deere, D.U. "Technical Description of Rock Cores for Engineering Purposes. " Rock Mech. and Eng. Geol. 1(1), (1964): 16-22.

Deere, D.U. Geological Classifications in Rock Mechanic in Engineering Practice, (Stagg, K.G. and Zienkiewicz, O.C. eds.) pp. 1-19. John Wiley & Sons, New York, 1968.

Deere, D.U. and Miller, R.P. "Engineering Classification and Properties for Intact Rock." Technical Report AFWL-TR-65-116, Kirtland Air Force Base, New Mexico, U.S.A., 1966.

Deere, D.U. and Patton, F.D. "Slope Stability in Residual Soils." Proc. 4th Panamerican Conf. Soil Mech. Found. Eng. Vol. III, pp. 125-144. San Juan, Purito Rico, 1971.

Dott, R.H. Jr. "Wacke, Gray Wacke and Matrix-What Approach to Immature Sandstone Classification ?" J. Sed. Petro. 34 (1964): 625-632.

Duncan, N. in Engineering Geology and Rock Mechanics Vol. II. p. 265 Leonard Hill, London, 1969.

Ege, J.R. "Stability Index foe Underground Structures in Granitic Rock." Geol. Soc. America Memoir 110, pp. 185-198, 1968.

Fairhurst, C. "Laboratory Measurement of Some Physical Properties of Rock " in 4th symposium on Rock Mech. (Hartman, H.L. ed.) Bull. Min. Ind. Exp. Sta. No. 76 pp. 118-135 The Pennsylvania State University, 1961.

Farmer, I.W. in Engineering Behaviour of Rocks, 2d ed., p. 208, Chapman and Hall Ltd, London 1983.

Folk, R.L. "The distinction between Grain Size and Mineral Composition in Sedimentary Rock Nomenclature." J. Geol. 62 (1954): 344-359.

Folk, R.L. in Petrology of Sedimentary Rocks. pp. 120-127, Hemphill's Book Stcre, Austin, Texas, 1968.

Fookes, P.G. and Horswill, P. "Discussion on Engineering Grade Zones." Proc. Conf. In-Situ Testing Soils and Rocks, pp. 53-57. Inst. Civ. Eng. Londdon, 1970.

Fourmaintranx, D. Characterization of Rocks; Laboratory Tests, Chapter IV in La Mecanique des Roces Appliquee aux Ouverages du Genie Civil, (Panet, M., et al. eds) Ecole National des Ponts et Chaussees, Paris, 1976.

Franklin, J.A. "Obervations and Tests for Engineering Description and Mapping of Rocks." Proc. 2d Cong. Int. Soc. Rock Mech. Vol. 1 Paper 1-3, pp. 11-16, Belgrade, 1970.

Franklin, J.A., Broch, E. and Walton, G. "Logging the Mechanical Character of Rock." Tran. Instn. Min. Metall. A80, 1970.

Franklin, J.A. and Chandra, R. "The Slake Durability Index" Int. J. Rock Mech. Min. Sci. 9(3), (1972): 325-342.

Gamble, J.C. "Durability-plasticity Classification of Shales and Other Argillaceous Rocks." Ph.D. Thesis, University of Illinoise, 1971.

Garson, M.S. and Mitchell, A.H.G. "The Geology of Tin Belt in Peninsular Thailand Around Phket, Phangna and Takua Pa." Overseas Memoir I Report Institue of Geological Science, London, 1975.

Geological Society Engineering Group Working Party "The Description of Rock Masses for Engineering Purposes." Q. Jl. Engng. Geol. 10(1977): 355-388.

Goodman, R.E. in Methods of Geological Engineering in Siscontinuous Rock p. 472. West Publishing Company, U.S.A., 1976.

_____. in Introduction to Rock Mechanics. p. 478 John Wiley & Sons, New York, 1980.

Greminger, M. "Experimental Studies of the Influencs of Rock Anisotropy on a Size and Shape Effects in Point-Load Testing" Int. J. Rock Mech Min. Sci. 19(1982): 241-246.

Guidicini, G., Nieble, C.M. and Cornides, A.T., "Analysis of Point Load Test as a Method for Preliminary Geotechnical Classification of Rocks." Bull. Int. Assoc. Eng. Geol. Vol. 7 pp. 37-52. Germany, 1973.

Gyenge, M. and Herget, G. "Pit Slope Mnual Supplement 3-2 Laboratory Tests for Design Parameters." CANMET Report 77-26, Cznada Centre for Mineral and Energy Technology Energy, Mines and Resources Canada, Ontario, Canada, 1977.

Hansagi, I. "Numerical Determination of Mechanical Properties of Rock and of Rock Masses." Int. J. Rock Mech. Min. Sci. 2(1965): 219-223.

Hawkes, I. and Mellor, M., "Uniaxial Testing in Rock Mechanics Laboratory" Engineering Geology 4(3), (1970): 177-285.

Hendron, A.J.Jr., Cording, E.J. and Aiyer, A.K. "Analytical and Graphical Methods for the Analysis of Slopes in Rock Masses." Nuclear Cratering Group Technical Report No. 36, U.S. Army Corps of Engineers, Urbama, Illinois, 1971.

Hiramatsu, Y. and Oka, Y. "Determination of the Tensile Strength of Rock by Compression Test of an Irregula Test Piece." Int. J. Rock Mech. Min. Sci. 3(1966): 89-99.

Hobbs, N.B. "Effects of Non-Linearity on the Prediction of Settlements of Foundations on Rock." Q.J. Eng. Geol. 6(1973): 153-168.

Hobbs, N.B. "The Prediction of Settlement of Structure on Rock." Conf. Settlement of Structures pp. 579-610. Cambridge, 1974.

Hoek, E. and Bray, J.w. in Rock Slope Engineering, 3d ed., p. 358, The Institute of Mining and Metallurgy, London, 1981.

Hoek, E. and Brown, E.T. in Underground Excavation in Rock. p. 527. The Institute of Mining and Metallurgy, London, 1980.

Hobbs, D.W. "The Tensile Strength of Rocks" Int. J. Rock Mech. Min. Sci. 1(1964): 385-396.

Hutchison, C.S. in Laboratory Handbook of Petrographic Techniques. pp. 49-55, Wiley-Interscience Publication, New York, 1974.

Jeager, J.C. and Cook, N.G.W. in Fundamentals of Rock Mechanics, 3d ed., p.585, Chapman and Hall, London, 1979.

Iida, R., and others "Geological Rock Classification of Dam Foundations." Rock Mech. in Japan 1(1970): 171-194.

John, K.W. "An Approach to Rock Mechanics." J. Soil Mech. Found. Div. ASCE 88(1), (1962): 1-30.

ISRM Committee on Labortory Tests in Rock Characterisation Testing and Monitoring (Brown, E.T. ed.) p. 211. Pergamon Press, London 1981.

Jumikis, A.R. in Rock Mechanics. p. 356. Trans Tech Publication, U.S.A., 1979.

Kenty, J.D. "Suggested Method of Testsfor Direct Shear Strength of Rock Core Specimens in Special Procedures for Testing Soil and Rock for Engineering Purposes." ASTM Special Technical Publication. No. 479, pp. 613-617, 1970.

Kruse, G.H., Zerneke, K.L., Scott, J.B., Johnson, W.S., and Nelson, J.S. "Approach to Classifying Rock for Tunnel Liner Design." Proc. 11th Symp. on Theory and Practice (Somerton, W.H. ed.) pp. 169-192. AIME, New York, 1970.

Krynine, P.D. The megascopic Study and Field Classification of Sedimentary Rocks in Sedimentary Rocks, (Carozzi, A.V. ed) pp. 64-100. Hutchinson & Ross, Inc., Pennsylvania, 1975.

Lauffer, H. "Gebirgsklassifizierung fur den Stollenbau! Geologie und Bauwesen 24(1), (1958): 46-51.

Little, A.L. "The Engineering Classification of Residual Tropical Soils." Proc. 7th Int. Cont. Soil Mech., pp. 1-10, Mexico, In Press, 1969.

Luangpitakchumpol, D. "Geomechanical Evaluation of Rock Masses in the Left Abutment and Power House Area at Khao Laem Damsite." MSc. Thesis Asian Institute of Technology, 1982.

Lundegard, P.D. and Samuels, N.D. "Field Classification of Fine Grained Sedimentary Rocks." J. Sed. Petro. 50(3), (1980): 0781-0786.

Malhotra, V.M. "Testing Hardened Concrete, Nonde-structive Methods." American Concrete Institute Monograph No. 9, 1976.

Mantajit, N. "Geology in Environmental and Ecological Investigation of Chiew Larn Project." Main Report, Vol. II, Team Consultant Engineers Co., Bangkok, 1981.

Markland, J.T. "A useful Technique for Estimating the Stability of Rock Slopes when the Rigid Wedge Sliding Type of Failure is Expected." Rock Mechanics Research Report No. 19, Imperial College, 1972.

McBride, E.F. "A Classification of Common Sandstones." J. Sed. Petro 33(3), (1963): 664-669.

McWilliams, J.R. "The Role of Microstructure in the Physical Properties of Rock in Testing Technique for Rock Mechanics." Special Techn. Publ. 402, pp. 175-189. American Society Testing Materials, 1966.

Mellor, M. and Hawkes, J. "Measurement of Tensile Strength by Diametral Compression of Discs and Annuli." Engineering Geology 5(2),(1971): 173-225.

Mitchell, M.H.G., Young, B. and Jataranipa, W. "The Phuket Group, Peninsular Thailand: A Paleczoic Geosynclinal Deposit." Geol. Mag. 107(4), (1970): 411-428.

Morgenstern, N.R. and Eigenbrod, K.D. "Classification of Argillaceous Soils and Rocks." J. Geotechnical Engin. Div., ASCE 100(10), (1974): 1137-1158.

Moye, D.G. "Engineering Geology for the Snowy Mountain Scheme" J. Instr. Civ. Engrs. Aust. 27(1955): 287-288.

Muller, L., and Hofmann, H. "Selection, Gompilation, and Assessment of Geological Data for the Slope Problem." Proc. Symp. on Planning Open Pit Mines pp. 153-170. Johannesburg, S. Afr., 1970.

N.C.S.A. "Quality of Concrete with Crushed Stone Aggregates." Final Report of Natural Crushed Stone Association, 1975.

Obert, L. and Duvall, W.I. in Rock Mechanics and the Design of Structures in Rock. p. 650. John Wiley & Sons Inc., London, 1967.

Olivier, H.J. "A New Engineering-Geological Rock Durability Classification" Engineering Geology 14(1979): 255-279.

Onodera, T.F. "Activities in Rock Mechanics in the Japanese Society of Soil Mechanics and Foundation Eng." Rock Mech. in Japan 1(1970)

Patton, F.D. "Multiple Modes of Shear Failure in Rock! in Proc. 1st Int. Soc. Rock Mech. pp. 509-513. Lisbon, 1966.

Pell, P.J.N. "The Use of Point-Load Test in Predicting the Compressive Strength of Rock Material. "Aust. Geomech. J. G5, N1 (1975): 54-56.

Peng, S.S. "Stress Analysis of Cylindrical Rock Discs Subjected to Axial Double Point-Loas." Int. J. Rock Mech. Min. Sci. 13 (1976): 97-101.

Proceq Sa "Concrete Test Hammer, Types L and Lr." Operation Instructions, Zurich, Switzerland, 1977.

Price, N.J. in Fault and Joint Development in Brittle and Semi-Brittle Rock. p. 176. Pergamon Press, London, 1981.

Protodyakonov, M.M. Methods of Determining the Shearing Strength of Rocks in Mechanical Properties of Rocks pp. 15-28. Israel Program for Scientific Translations, Jerusalem, 1969.

Reichmuth, D.R. "Correlation of Force-Displacement Data with Physical Properties of Rock for Percussive Drilling Systems" in 5th Symposium on Rock Mech. (Fairhurst, C. ed.) pp. 33-59. Pergamon, Oxford, 1963.

Reichmuth, D.R. "Point-Load Testing of Brittle Materiarials to Determine Tensile Strength and Relative Brittleness," in 9th Symposium on Rock Mechanics pp. 134-159., 1968.

Roberts, A., in Geotechnology; An Introductory Text for Students and Engineers. p. 347. Pergamon Press, London, 1977.

Rutledge, J.C. "Engineering Classifications of Rock for the Determination of Tunnel Support." in Symposium on Tunnelling in New Zealand. pp. 3.1-3.25 Vol. 3, The New Zealand Institution of Engineers, Wellington, 1977.

Rzhevoky, V. and Novik, G. in The Physics of Rocks. p. 320. MIR Publishers, Moscor, 1971.

Selley, R.C. in An Introduction to Sedimentology. pp. 77-91, Academic Press Inc. Ltd., London, 1982.

Selmer-Olsen, R. and Blindheim, O.T. "On the Drillability of Rock by Percussive Drilling." Proc. 2d Cong. Int. Soc. Rock Mec Mech. paper 5-8, Vol. 2, Belgrade, 1970.

Sjogren, B., Ofsthus, A., and Sandberg, J. "Seismic Classification of Rock Mass Qualities." Geophysical Prospecting 27(1979): 409-442.

Stini, I. in Tunnelbaugeologie p. 366, Springer-Verlag, Vienna, 1950.

Talbot, C. in Lecture Notes to Short Course on Engineering in Developing Countries. Bangkok, Thailand, 1979.

Terzaghi, K. Rock Defects and Loads on Tunnel Supports in Rock Tun Tunnelling with Steel Supports. (Proctor, R.V. and White, T. eds.) pp. 15-99, Commercial Shearing and Stamping Co., Youngstown, 1946.

The Geological Society Society Engineering Group Working Party. "The Description of rock Masses for Engineering Purposes." Q. Jl. Engna. Geol. 10(1977): 355-388.

The Committee on Definitions and Standards of the Geotechnical Engineering Division. "SI Units for Geotechnical Engineering" J. Geotech. Eng. 109(12), (1983):

Underwood, L.B. "Classification and Identification of Shales." J. Soil Mech. Found. Div., ASCE 93(6), (1967): 97-116.

Vutukuri, V.S., Lama, R.D. and Saluji, S.S. in Handbook on Nechanical Properties of Rocks Vol.1 p. 280. Trans Tech Publications, Germany, 1974.

Wickham, G.E., Tiedeman, H.R. and Skinner, E.H. "Support Determination Based on Geologic Predictions." in Proc. First North Amer. Rapid Excavn. & Tunnelling Conf., A.I.M.E., pp. 43-64., 1974.

Zoldners, N.G. "Calibration and Use of Impact Test Hammer." American Concrete Institute Journal 54(2), (1957): 161-165.

APPENDICES

Appendix A

A-1 Summary of joint survey results

A-2 Location of core specimens in laboratory tests

A-3 Input data form of Geomechanics Classification

Appendix B

B-1 Computer program for point-load test

B-2 Computer program for Schmidt rebound hardness test

B-3 Computer program for pulse velocity test

B-4 Computer program for uniaxial compression test

B-5 Computer program for fitting linear regression (least square)

Table A-1 Summary of joint survey results.

Type of Outcrop and Location	Orientation of Joint (strike & dip)			
	A	B	C	D
Cut slope, First Aid Station	359/84,30/69		140/69	
Cut slope, Carpenter workshop	38/74			285/69,325/56
Cut slope, EGAT labour camp		80/4	156/46,18079	
Cut slope, Guest House		75/55	170/72	290/78
Cut slope, Engine workshop	360/69		180/90	284/69,288/50 300/84
Cut slope, Engineer house		95/55	170/69	290/60
Cut slope, EGAT temporary mess		96/46,112/50	166/74	
Natural, Right dam axis		75/55		284/64
Natural, Left dam axis		62/64		284/64
Road cut, Inlet power tunnel	28/84	70/60	178/50	
Natural, Khlong Seng river		70/76		320/84
Natural, Khlong Saeng meander			180/80	300/64,290/74
Cut slope, Right & Left of out let Diversion tunnel channel	20/90	117/84	170/58,222/90	
Road cut, Spillway channel to borehole SW 1	28/86	125/76		300/64
Road cut, Access road to borehole SW 2 and SW 3				286/84,298/69
Quarry, Road to new blasting site	24/90		160/50,165/74 204/90	286/74
Top heading wall, ch. 35-85	25/84	90/44,119/44		261/74
Top heading wall, ch. 85-135		120/84		260/69
Top heading wall, ch. 135-185	21/84	76/70,100/50 128/78		280/68
Top heading wall, ch. 185-235		60/85,135/90	190/84	315/90
Top heading wall, ch. 235-285		68/50,114/41		284/67

Table A-1 (cont.)

Type of Outcrop and Location	Orientation of Joint (strike & dip)			
	A	B	C	D
Top heading wall, ch. 285-335		82/80		270/75
Top heading wall, ch. 335-385	24/84	90/79,131/20		
Top heading wall, ch. 385-435	20/74	50/90,140/90		260/74,312/86
Top heading wall, ch. 435-485		76/74		280/79,291/25
Top heading wall, ch. 485-517		90/20,72/80		2900/68
Cut slope, Outlet portal elev. 24-38 m	15/90	79/25,115/72	195/90	
Cut slope, Outlet portal elev. 38-47 m	20/90	86/74,130/80	200/90	290/74
Cut slope, Inlet portal elev. 18-30	26/80			296/79
Cut slope, Inlet portal elev. 30-41.50	22/90		202/90	265/82,315/74
Cut slope, Inlet portal elev. 41.50-47.30 m	25/90		205/90	263/76
Cut slope, Inlet portal elev. 47.30-60.oo (1)	22/90		202/90	263/76
Cut slope, Inlet portal elev. 47.30-60.00 (2)	24/90	92/48		281/84
Cut slope, Inlet portal elev. 60.00-80.00 (1)	25/76	125/90	173/71	305/90
Cut slope, Inlet portal elev. 60.00-80.00 (2)	20/84		165/55	268/84
Cut slope, Inlet portal elev. 60.00-80.00 (3)			173/40	282/70,315/50
Cut slope, Inlet portal elev. 80.00-upper			185/69	286/41,279/50 297/59

Table A-2 Location of core specimens in laboratory tests.

Rock Type	Designation Hole No.	Locality	Elevation		Total Depth m	Testing Boring Depth m.
			Colar	Bottom		
Sark Gwke	DH 1	River Channel	+10.482	-13.468	23.95	23.40-23.70 42.20-42.40
Sark Gwke	DH 2	River Channel	+13.401	-56.599	70.00	1.10- 1.30 54.20-54.50
Gwke Sark Gwke	DH 3	River Channel	+12.814	-57.816	70.00	15.05-15.33 30.30-30.40 59.00-59.30
Gwke "	DH 4	Right Abutment	+43.516	-35.484	70.00	21.71-22.13 66.00-66.40
Gwke Sark Gwke	DH 5	Left Abutment	+21.554	-48.446	70.00	14.90-15.40 39.00-39.20 58.40-58.60
Sark Gwke "	DH 6	Right Abutment	+84.287	+14.087	70.20	1.50- 1.90 35.40-35.80 40.00-40.40
Gwke " " Sark	DH 7	Left Abutment	+31.892	-38.608	70.50	42.00-42.34 43.50-44.00 46.50-46.70 66.00-70.50
Gwke "	DH 8	Right Saddle	+80.567	+9.46	71.10	42.80-42.90 43.00-43.35
Gwke " " "	DH 9	Left Abutment	+45.087	-25.363	70.45	25.50-52.88 49.70-49.80 55.30-55.40 57.60-58.00
Gwke "	DH 11	Left Abutment	+57.250	-12,850	70.10	40,70-40.90 60.65-61.05

Table A-2 (cont.)

Rock	Designation	Locality	Elevation		Total Depth m	Testing Boring Depth m
			Colar	Bottom		
Gwke	DH 13	Left	+75.280	+4.780	70.50	51.20-51.40
"						59.05-59.53
Gwke	NSP 1	Diversion Tunnel	+100.73	+50.434	50.30	45.40-45.80
Gwke	NSP 2	Diversion Tunnel	+96.250	+53.350	42.90	25.00-25.30
"						28.80-29.00
"						30.27-30.61
Gwke	NSP 3	Diversion Tunnel	+87.544	+37.494	50.05	25.40-25.70
Gwke	DD 2	Power House	+14.289	—	—	32.00-32.20
Gwke	DD 3	Power House	+20.412	—	—	34.00-34.30
Gwke	DD 4	Left Abutment	+27.730	-42.270	70.00	51.00-51.30
Gwke	DD 5	Left Abutment	+91.080	+49.65	50.00	33.00-33.30
Sark	DD 25	Diversion Tunnel	+87.200	+22.200	65.00	7.00 -7.20
"						14.00-14.30
"						15.43-15.73
Gwke						59.20-59.45
"						61.00-61.30
"						61.80-62.00
"						64.00-64.30

Table A-3 Input data form of Geomechanics Classification of jointed rock masses (revised) (after Bieniawski, 1979).

Name of project:
Site of survey:
Conducted by:
Date:

STRUCTURAL REGION	ROCK TYPE AND ORIGIN

DRILL CORE QUALITY R.Q.D.*		WALL ROCK OF DISCONTINUITIES
Excellent quality:	90 - 100%	Unweathered
Good quality:	75 - 90%	Slightly weathered
Fair quality:	50 - 75%	Moderately weathered
Poor quality:	25 - 50%	Highly weathered
Very poor quality:	<25%	Completely weathered
*R.Q.D. = Rock Quality Designation		Residual soil

GROUND WATER	STRENGTH OF INTACT ROCK MATERIAL
INFLOW per 10 m of tunnel length: litres/minute	Designation: Uniaxial compressive strength, MPa — OR — Point-load strength index, MPa
or	Very high: Over 250 — >10
WATER PRESSURE: kPa	High: 100 - 250 — 4-10
or	Medium high: 50 - 100 — 2-4
GENERAL CONDITIONS (completely dry, damp, wet, dripping or flowing under low/medium or high pressure):	Moderate: 25 - 50 — 1-2
	Low: 5 - 25 — < 1
	Very low: 1 - 5

SPACING OF DISCONTINUITIES

		Set 1	Set 2	Set 3	Set 4
Very wide:	Over 2 m				
Wide:	0,6 - 2 m				
Moderate:	200 - 600 mm				
Close:	60 - 200 mm				
Very close:	<60 mm				

STRIKE AND DIP ORIENTATIONS

Set 1	Strike: (average)	(from ... to ...)	Dip: (angle)	(direction)
Set 2	Strike:	(from ... to ...)	Dip:	
Set 3	Strike:	(from ... to ...)	Dip:	
Set 4	Strike:	(from ... to ...)	Dip:	

NOTE: Refer all directions to magnetic north.

CONDITION OF DISCONTINUITIES

PERSISTENCE (CONTINUITY)		Set 1	Set 2	Set 3	Set 4
Very low:	<1 m				
Low:	1 - 3 m				
Medium:	3 - 10 m				
High:	10 - 20 m				
Very high:	> 20 m				
SEPARATION (APERTURE)					
Very tight joints:	<0,1 mm				
Tight joints:	0,1 - 0,5 mm				
Moderately open joints:	0,5 - 2,5 mm				
Open joints:	2,5 - 10 mm				
Very wide aperture	> 10 mm				
ROUGHNESS (state also if surfaces are stepped, undulating or planar)					
Very rough surfaces:					
Rough surfaces:					
Slightly rough surfaces:					
Smooth surfaces:					
Slickensided surfaces:					
FILLING (GOUGE)					
Type:					
Thickness:					
Uniaxial compressive strength, MPa					
Seepage:					

MAJOR FAULTS OR FOLDS

Describe major faults and folds specifying their locality, nature and orientations.

GENERAL REMARKS AND ADDITIONAL DATA

NOTE:
(1) For definitions and methods consult ISRM document: *'Quantitative description of discontinuities in rock masses.'*
(2) The data on this form constitute the minimum required for engineering design. The geologist should, however, supply any further information which he considers relevant.

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100 ! ************************************************************
110 ! * Thesis Title On: Geomechanical Aspects and Their Applica-*
120 ! * tion to the Diversion Tunnel Stability at Chiew Larn Dam *
130 ! * Site, Changwat Surathani                                 *
140 ! *      Pursued By: Danupon Tonnayopas, BSc. (Eng. Geol.)   *
150 ! * Name of Program: Point-Load Test Based on Greminger(1982)*
160 ! *         Used By: Hewlett-Packard HP-85 computer          *
170 ! ************************************************************

180 OPTION BASE 1@ CLEAR
190 DIM A(50),B(50),C(50),D(50),L(50),S(50),X1(1),P(50)
200 DISP "FOR CORRECT DATA INPUT *,*"
210 DISP "No. OF DATA";@ INPUT N
220 FOR I=1 TO N
230 DISP "P(";I;"),D(";I;"),L(";I;")=";
240 INPUT A$,R$,L$
250 IF UPC$(A$)="*" AND UPC$(R$)="*" THEN I=I-1 @ GOTO 230
260 P(I)=VAL(A$) @ D(I)=VAL(R$) @ L(I)=VAL(L$)
270 ! Calculation of Point-Load Strength Index
280 A(I)=.834*P(I)
290 B(I)=SQR(50)*(D(I)*L(I))^.75
300 ! S=Point-load Strength Index (Is)
310 S(I)=A(I)/B(I)*1000
320 ! Relationship between UCS & Is
330 C(I)=24*S(I)
340 ! C=UCS=Uniaxial Compressive Strength
350 NEXT I
360 REDIM S(N),C(N)@ X=AMIN(S) @ XO=AMAX(S)
370 MAT X1=CSUM(S)@ X2=X1(1)/N
380 MAT X1=CSUM(C)@ X3=X1(1)/N
390 MAT A=S.S@ MAT X1=(SUM(A)/N)@ X4=SQR(X1(1)-X2^2)
400 PRINT "   P      D    L    Is      "
410 PRINT "                        D      c" @ PRINT
420 FOR J=1 TO N
430 PRINT USING "3D.2D,1X,3D.1D,1X,3D,3X,1D.2D,2X,3D.2D" ; P(J),D(J)
,L(J),S(J),C(J)
440 PRINT USING "3D.2D,1X,3D.1D,1X,3D,3X,1D.2D,2X,3D.2D" ; P(J),D(J)
,L(J),S(J),C(J)
450 PRINT "Max. Is =";INT(XO*1000)/1000;"MPa"
460 PRINT "Min. Is =";INT(X*1000)/1000;"MPa"
470 PRINT "Mean Is =";INT(X2*1000)/1000;"MPa"
480 PRINT "Mean  =";INT(X3*1000)/1000;"MPa"
490 PRINT "Std. Is =";INT(X4*1000)/1000;"MPa"
500 PRINT "Std. of mean Is =";INT(X4/SQR(N)*1000)/1000;"MPa"
510 MAT A=(0)@ MAT B=(0)@ MAT C=(0)@ MAT D=(0)@ MAT L=(0)@ MAT P=(0)
@ MAT S=(0)
520 END
```

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100 ! ************************************************************
110 ! * Thesis Title On: Geomechanical Aspects and Their Applica-*
120 ! * tion to the Diversion Tunnel Stability at Chiew Larn Dam *
130 ! * Site, Changwat Surathani                                 *
140 ! *      Pursued By: Danupon Tonnayopas, BSc. (Eng. Geol.)   *
150 ! * Name of Program: Schmidt Rebound Hardness Test           *
160 ! *         Used By: Hewlett-Packard HP-85 computer          *
170 ! ************************************************************
180 OPTION BASE 1@ CLEAR
190 DIM A(500),R(500),C(500),D(500)
200 DISP "FOR CORRECT DATA INPUT *,*"
210 DISP "No. OF DATA";@ INPUT N
220 FOR I=1 TO N
230 REM " d=density; R=Schmidt rebound reading value"
240 DISP "d(";I;"),R(";I;")=";
250 INPUT A$,R$
260 IF UPC$(A$)="*" AND UPC$(R$)="*" THEN I=I-1 @ GOTO 240
270 A(I)=VAL(A$) @ R(I)=VAL(R$)
280 ! Calculation of UCS & Tangent Modulus
290 A0=1+.00874*A(I)*R(I)
300 ! C=Uniaxial Compressive Strength (qu)
310 C(I)=10^A0
320 ! D=Tangent Modulus Et(lin); E=Tangent Modulus Et(sq)
330 D(I)=600*A(I)*R(I)-20300
340 E(I)=187*(A(I)^2*R(I))-7860
350 NEXT I
360 PRINT @ PRINT "                          lin.          sq."
370 PRINT TAB(4);"q";TAB(11);"Et";TAB(28);"Et"
380 PRINT "   u" @ PRINT
390 FOR J=1 TO N
400 PRINT USING "4D.2D,3X,2(5D.2D,3X)" ; C(J),D(J),E(J)
410 NEXT J
420 END
```

Appendix B-3

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100 ! ************************************************************

110 ! * Thesis Title On: Heomechanical Aspects and Their Applica-*
120 ! * tion to the Diversion Tunnel Stability at Chiew Larn Dam *
130 ! * Site, Changwat Surathani *
140 ! *      Pursued By: Danupon Tonnayopas, BSc. (Eng. Geol.)   *
150 ! * Name of Program: Pulse Velocity Test                     *
160 ! *          Used By: Hewlett-Packard HP-85 computer         *
170 ! ************************************************************

180 OPTION BASE 1@ CLEAR
190 DIM A(100),B(100),C(100),D(100),P(100),S(100),G(100)
200 DIM H(100),M(100),O(100),K(100),E(100),X(100),Y(100)
210 DISP "FOR CORRECT DATA    INPUT *,*,*,*"
220 DISP "No. OF DATA";@ INPUT N
230 FOR I=1 TO N
240 REM "d=density; Tp=P-wave time; Ts=S-wave time; h=height"
250 DISP "d(";I;"),Tp(";I;"),Ts(";I;"),h(";I;")=";
260 INPUT A$,B$,C$,D$
270 IF UPC$(A$)="*" AND UPC$(B$)="*" AND UPC$(C$)="*" AND UPC$(D$)="
*" THEN I=I-1 @ GOTO 250
280 A(I)=VAL(A$) @ B(I)=VAL(B$) @ C(I)=VAL(C$) @ D(I)=VAL(D$)
290 ! P=P-wave velocity (Vp); S=S-wave velocity (Vs)
300 P(I)=D(I)/B(I)
310 S(I)=D(I)/C(I)
320 ! G=modulus of rigidity (G); H=stiffness modulus (Y)
330 G(I)=A(I)*S(I)^2/10.19716212*100
340 H(I)=A(I)*P(I)^2/10.19716212*100
350 X(I)=P(I)^2-2*S(I)^2
360 Y(I)=P(I)^2-S(I)^2
370 ! M=Poisson's ratio (Pd); O=Lame's constant (L)
380 M(I)=X(I)/(2*Y(I))
390 O(I)=A(I)*X(I)/10.19716212*100
400 Z(I)=3*P(I)^2-4*S(I)^2
410 ! K=bulk modulus
420 K(I)=A(I)*Z(I)/3/10.19716212*100
430 E(I)=A(I)*S(I)^2*Z(I)/Y(I)/10.19716212
440 NEXT I
450 PRINT @ PRINT "    Vp          Vs        Pd      Ed      Y        G
     L       K "
460 PRINT "       9          9                4       4       4        4
    4"
470 PRINT "   X10        X10             X10     X10     X10      X10
X10 "
480 PRINT TAB(2);"cm/sec";TAB(11);"cm/sec";TAB(28);"MPa";
490 PRINT TAB(36);"MPa";TAB(44);"MPa";TAB(52);"MPa";TAB(60);"MPa"
500 PRINT
510 FOR J=1 TO N
520 PRINT USING 540 ; P(J),S(J),M(J),E(J),H(J),G(J),O(J),K(J)
530 NEXT J
540 IMAGE 2(1D.4D,3X),1D.3D,3X,5(1D.3D.3X)
550 END
```

Appendix B-4

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100 ! ************************************************************
110 ! * Thesis Title On: Geomechanical Aspects and Their Applica-*
120 ! * tion to the Diversion Tunnel Stability at Chiew Larn Dam *
130 ! * Site, Changwat Surathani *
140 ! *      Pursued By: Danupon Tonnayopas, BSc. (Eng. Geol.)   *
150 ! * Name of Program: Uniaxial Compression Test               *
160 ! *          Used By: Hewlett-Packard HP-85 computer         *
170 ! ************************************************************
180 OPTION BASE 1@ CLEAR
190 DIM P(150),B(150),E1(150),E2(150),E3(150),C(150),D(150)
200 DISP "FOR CORRECT DATA INPUT *"
210 ! B=Original cross-section area in mm
220 DISP "No. OF DATA";@ INPUT N
230 DISP "HOW MANY CROSS-SECTION AREA";@ INPUT B
240 FOR I=1 TO N
250 REM "P=compressive load; E1=axial strain; E2=lateral srain
260 DISP "P(";I;"),E1(";I;"),E2(";I;")=";
270 INPUT P$,A$,F$
280 IF UPC$(P$)="*" AND UPC$(A$)="*" AND UPC$(F$)="*" THEN I=I-1 @ G
OTO 260
290 P(I)=VAL(P$) @ E1(I)=VAL(A$) @ E2(I)=VAL(F$)
300 ! Calculation of Uniaxial Compressive Strength @ Poisson's Ratio
 @ Volumetric Strain
310 C(I)=P(I)/B
320 D(I)=E1(I)/E2(I)
330 E3(I)=E1(I)-2*E2(I)
340 NEXT I
350 PRINT TAB(2);"Uniaxial Compressive Strength";TAB(35);"Poisson Ra
tio";
360 PRINT TAB(54);"Volumetric Strain";
370 PRINT TAB(13);"MPa" @ PRINT
380 FOR J=1 TO N
390 PRINT USING 380 ; C(J),D(J),E3(J)
400 NEXT J
410 IMAGE 10X,3D.3D,22X,1D.4D,25X,1D.4D
420 END
```

Appendix B-5

```
100 ! ************************************************************
110 ! *Thesis Title On: Gomechanical Aspects and Their Applica-  *
120 ! *tion to the Diversion Tunnel Stability at Chiew Larn Dam  *
130 ! *Site Surathani                                           *
140 ! *       Persued By: Danupon Tonnayopas, BSc.(Eng Geol.)   *
150 ! * Name of Program: General Linear Regression              *
160 ! *          Used By: Hewlett-Packard HP-85 computer        *
170 ! ************************************************************
180 OPTION BASE 1@ CLEAR @ GCLEAR
190 DIM X1(50,2),X2(2,50),Y(50),C(2),X3(2,2),X4(50),Y1(50)
200 MAT X1=(1)@ GO=0 @ P1=15 @ P2=92
210 DISP "FOR CORRECT DATA INPUT *"
220 ALPHA @ DISP "No. OF DATA";@ INPUT N
230 REDIM X1(N,2),X2(2,N),Y(N),X4(N),Y1(N)
240 FOR I=1 TO N
250 DISP "FOR CORRECT DATA INPUT *"
260 DISP "X";I;",Y";I;"=";@ INPUT A$,B$
270 IF UPC$(A$)="*" AND UPC$(B$)="*" THEN I=I-1 @ GOTO 260
280 Y(I)=VAL(B$) @ X1(I,2)=VAL(A$)
290 NEXT I
300 MAT X2=TRN(X1)
310 MAT X3=X2*X1
320 MAT C=X2*Y
330 MAT C=SYS(X3,C)
340 MAT Y1=X1*C
350 MAT X4=X1(,2)
360 IF GO=1 THEN 480
370 Z0=AMAX(X4) @ Z0=Z0+Z0*.1 @ Z1=AMIN(X4)
380 Z3=AMAX(Y1) @ Z3=Z3+.1*Z3 @ Z4=AMIN(Y1)
390 IF Z1>0 THEN Z1=0
400 IF Z4>0 THEN Z4=0
410 Z5=IP(.1*(Z0-Z1)) @ Z6=IP(.1*(Z3-Z4))
420 IF Z5=0 THEN Z5=1
430 IF Z6=0 THEN Z6=1
440 LIMIT 0,97.155,0,72.771
450 LOCATE 15,124,15,90
460 SCALE Z1,Z0,Z4,Z3
470 LAXES -Z5,Z6,Z1,Z4,2,2,4
480 SETUU
490 MOVE 0,C(1)
500 FOR J=1 TO N
510 MOVE X1(J,2),Y(J)
520 IMOVE -(.1*Z5),0
530 IDRAW .2*Z5,0
540 IMOVE -(.1*Z5),-(.1*Z6)
550 IDRAW 0,Z6*.2
560 IMOVE 0,Z6*.2 @ IMOVE -(Z5*.2),0 @ LABEL GO
570 NEXT J
580 MOVE 0,C(1)
590 FOR J=1 TO N
600 DRAW X1(J,2),Y(J)
610 NEXT J
620 SETGU
630 MOVE P1,P2
640 LABEL GO;"IS";" F(X)=";INT(C(1)*10^3)/10^3;"+";INT(C(2)*10^3)/10^3;"-
X"
650 IF GO=0 THEN GO=1 @ P2=85 @ GOTO 220
660 PRINT @ PRINT @ PRINT
670 END
```

BIOGRAPHY

Mr. Danupon Tonnayopas, was born in Amphoe Haad Yai, Changwat Songkhla, southern Thailand, on July 30, 1956. He attended Khon Kaen University from 1975 to 1980, when he graduated with a degree of B.Sc. in Geology. After the graduation he worked 6 months as a geologist in the Watershed Research Section, Watershed Management Division, Royal Forestry Department. Then he resigned from the work to enter the graduate school of Chulalongkorn University.