

## ROBERT A N MACKEAN - Consultant in Engineering Geology

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### EDUCATION

- BSc Honours in Geology, Dundee and Illinois Universities (1987)
- MSc Engineering Geology, Imperial College, London University (1989)
- DIC Geostatistics in Ground Engineering, Imperial College (1989)

### AFFILIATIONS

- Member of the Geological Society of London (1989), Chartered Geologist (1992)
- Member of the institute of Mining and Metallurgy (1992), Chartered Engineer (1993)

### EXPERIENCE

**1999 - 2010** - Geo- Design - Director and Consultant in Engineering Geology

**1996 - 1999** - Atkins China Ltd - Principal Engineering Geologist

**1994 -1996** - Resident Geotechnical Engineer, Ting Kau Bridge and Approach Viaducts, Hong Kong. Geo-Design (in association with Flint and Neil Partnership)

**1990 - 1994** - Engineering Geologist, Engineering Geology Ltd

**1987 - 1989** - Geologist, Scott Wilson Kirkpatrick

**1999 - 2010** - **Geo-Design - Director and Consultant in Engineering Geology**

### Principal Current Areas of Specialisation

Robert leads the application of engineering geology to the planning, investigation, design and construction of major civil and mining engineering structures, within the Geo-Design Group. He has particular expertise in assessments and design assignments for underground excavations, in particular large span openings and long tunnels in complex geological settings. He also has significant experience in assessments related to high rock slopes and heavily loaded foundations on rock.

Several recent assignments have required establishing the feasibility of rock engineering schemes in unprecedented settings in terms of ground conditions and proximity to existing structures.

Robert has been providing technical input to projects in Hong and the Far East since 1993. He was successful in negotiating night time blasting for the safe widening of Tuen Mun Road and established approval for West Rail drill and blast tunnel that past close under WSD tunnel No.3 (supplying Tuen Wan)

Robert has been commissioned to provide expert opinion on the investigation and assessment of ground conditions and their influence on several major construction schemes.



## Selected Major Projects

- Brisbane Airport Link - Independent review of ground conditions relating to the feasibility of large span cavern construction in shallow cover urban setting in weak sedimentary rocks.
- Harbour Area Treatment Scheme, Hong Kong – Review of layout alternatives for adit complexes at the base of deep shafts. Review of ground conditions, production of models and concept design of temporary support schemes.
- Express Rail Link (XRL), Hong Kong. Specialist inputs to detailed design of large span bifurcation caverns and leading hydrogeological assessment of low cover rock tunnel in urban location.
- West Island Line, Hong Kong. Discipline Leader for the Scheme and Detailed design of two cavern stations in shallow rock cover urban environment. Design including UDEC modeling, excavation geometry and sequencing, temporary support and specification. Hydrogeological impact assessment issues. Liaison with Government departments.
- Gautrain Project - South Africa. Independent Checking Engineer of all large span underground openings and deep excavations in rock.
- Gerrards Cross Tunnel Collapse, UK. Leading engineering geological aspects of investigation in to the collapse of a large span (20m), precast segmental arch - fill structure some 300m in length over a live railway.
- Gibe II - Ethiopia. Independent assessment of ground conditions and collapse mechanisms of TBM tunnel under very high cover, and flowing ground.
- Shatin to Central Link NEX2202. Review of options for cavern layout and ground related risk.
- Dublin Metro - Detailed review of station cavern feasibility in central location, in highly anisotropic bedded rock mass, using shotcrete linings.
- Gautrain Project - South Africa. Comprehensive alignment geological assessment for 15km urban high speed rail way scheme. Initiation and development of cavern options for Sandton Station. Preliminary Design of tunnel and cavern initial and final support.
- Dudley Limestone Mines. Detailed stability assessment of large mine cavern and associated openings including canal basin and openings to surface (Seven Sisters). Outline Mine Stabilisation Scheme. Assistance with preparation of bid for the Peoples Millions Lottery.
- Kufra – Tazerbo Pipeline, Libya. Part of Great Man Made River Project. Peer review of rippability assessment in desert environment.
- GEO Special Projects, Hong Kong. Guidance Document for HK Government. The preparation of 'Prescriptive Design Measures for the Design of Rock Slopes'.
- DTSS Project - Singapore. Assessment of causes of launch chamber collapse including failure of shotcrete lining. Review of expected and encountered ground conditions. Planning and interpretation of additional site investigation.
- Tel Aviv to Jerusalem Railway: Independent review of station cavern feasibility (two adjacent 23m diameter caverns).
- Shatin to Central - Hong Kong (SDC 700), Atkins Meinhardt. Specialist technical review and design of station cavern schemes. Review of ground conditions and assessment of feasibility of construction of new underground stations in an urban setting in close proximity to existing structures. Review of cavern



construction constraints, impacts and options. Design management of preliminary design package including UDEC modeling, excavation geometry and sequencing, temporary support specification.

- Shatin to Central - Hong Kong (SDC 300). Mott Atkins. Review consultant for proposed station cavern design (Ho Man Tin Station) and review of tender documentation.
- Citytunneln Projects, Malmo, Sweden Triangeln Station Cavern. Design and Construction Feasibility Assessment of large span station cavern, independent geotechnical assessment and preparation of outline cavern design. Section leader of review team for assessment of ground conditions and preparation of detailed interpretation of geological, geophysical and geotechnical data for cavern with shallow cover and many structures above including two existing schools. Excavation staging, temporary support and final lining arrangement.
- Dublin Port Tunnel – Vehicular Cross Over Caverns. Design and project management of Preliminary and Detailed Design and construction implementation of large span underground excavation complex comprising a cross over, lay-by enlargement cavern and intervening E&M rooms in weak bedded rock and glacial materials with shallow rock cover. Design was unprecedented in terms of span, proximity of openings and low rock cover.
- Bridge G12, Egnatia Highway. Advising on all geotechnical aspects of an Independent Design check of a high level viaduct structure across steep mountainous terrain, in a seismically active region.
- Beit Zait Highway Tunnel, Israel in bedded limestone sequence. Concept design through to detailed design (ongoing) for twin three lane highway in bedded weak limestone sequence in variable, including very low cover in close proximity to existing structures. Cross over caverns and variable span bifurcation sections.
- Rosia Montana Mine, Romania. Underground inspection of extensive recent and historic mine workings (Roman) to evaluate options for underground museum.
- Thelwall Old Viaduct, Flint and Neill Partnership. Category 3 design check of existing foundation appraisal. Evaluation of historical geotechnical and piling data. Assessment of pile capacities in relation to altered pile loads.
- Northwich Salt Mine, UK. Detailed Review of Site Investigation Scope preparation of detailed geological and hydrogeological models as a basis for assessing Salt Mine Filling and Stabilisation.
- LPG Cavern, Zhuhai. Review of ground conditions for proposed gas cavern, Tender Design.
- Communication Masts, UK. Review and independent check of foundations designs for 300m tall masts and associated anchor blocks.
- Bincombe Tunnel / A353 interface. Dorset County Council. Assessment of potential impacts of road construction on existing railway tunnel and backfilled construction shafts.
- Implementation of Eurocodes, Parsons Brinkerhoff. Review of Rock Bolts and Tunnels.
- Central Kowloon Route, Hong Kong. Review consultant for proposed tunnel in urban environment. Review of Geotechnical Interpretations, Tunnel Design, Cross Over Cavern Options, and Construction options (TBM versus drill and blast) and groundwater inflow assessments.
- Mouchel / Railtrack, SACP (tunnels) review of assessment strategy for whole life tunnel maintenance costs.
- GEO Special Projects, Hong Kong. Guideline Document for HK Government. Improved Methodology for Geotechnical Assessment for the Planning of Major Highways 'Assessment of Cutting Options vs. Tunnelling or Other Options'.



- Channel Tunnel Rail Link. Independent Design Check of temporary support for large diameter 3.2km long single bore twin track, North Downs Tunnels, in weak limestone (Chalk).
- Railtrack UK. Review of approach for assessment of maintenance requirements for Railtrack's 700 tunnels, including classification, inspection and assessment of whole life costs.
- Brighton and Hove Stormwater Project UK. 5km 6m diameter storage tunnel in weak limestone (Chalk). Expert assessment of adequacy of site investigation in terms of scope, in relation to the scheme. Detailed appraisal of logging and logging procedures. Technical reports prepared on the engineering behaviour of chalk in relation to TBM tunnelling methods.
- BG Technology, UK. Gas Storage Cavern Study. Review of Geological Conditions for Siting of Deep Pressurized Gas Storage Caverns.
- Aznalcollar Mine, Spain. Review of geological conditions relating to stability of slopes to large open cast mine.
- Halifax Sewerage Reconstruction Stage 2A. Appointed Expert in the matter if an arbitration relating to unexpected ground conditions. Provision of expert assessment of ground conditions and inferred tunneling conditions.
- Dublin Port Tunnel 4.4km twin tube road tunnel – Tender Design. Review of ground conditions, preparation of geological model, temporary support design and excavation methodology development. Assessment of groundwater inflows in relation to drill and blast and TBM excavation.
- Route 10, Hong Kong, 4.1km and 1.7km bored road tunnel. Specialist Review of Site Investigation Scope Alignment Geological Conditions and Tunnelling Methodology.
- Casecnan Hydro and Transfer Project, Philippines, 8km transfer tunnel. Review of Ground Conditions in relation to assessment of potential cause and extent of time dependent rock mass deterioration.
- Watchet Sewerage Scheme, UK. Expert Independent Review of Site Investigation Scope, Ground Conditions and Inferred Tunnelling Conditions in relation to TBM excavation, Preparation of Expert Reports.
- Westmount Quarry, Jersey. Investigative assessment and stability review of a major landslide in disused quarry. The slip comprised a complex and deep seated failure in a rock slope. Review of stabilisation options is ongoing.
- Clifton Suspension Bridge, UK. Specialist advisor to the Bridge Trustees on the long term stability of the Bridge foundations under earthquake loading. Ongoing.
- Park Heights Development, Jersey. Investigative assessment of large rock slope failure adjacent to a high rise residential development. Design and construction feasibility of remedial measures.
- St Helier Storm Water Relief, Jersey. Detailed Review of Site Investigation Data. Preparation of Detailed Reference Ground Model and a Series of Expert Report Submissions.
- Bakun Hydropower Project, Philippines. Review of rock mass conditions in relation to potential variations in rock mass modulus for pressure tunnel lining design.

#### **1996 - 1999 ATKINS CHINA LTD - PRINCIPAL ENGINEER**

Principal tasks comprised acting as both technical team leader for all geotechnical and tunneling design inputs to major underground construction schemes in Hong Kong, together with Section Design manager for underground elements of the projects. Such assignments required the co-ordination of all technical areas, including deployment of sub consultants, liaison with third parties and presentation to government departments at the highest level.



- Central Kowloon Route - Design and Construction Assignment. Technical Leader of geotechnical and tunnel teams undertaking route planning, site investigation (HK\$10 million) and design of both bored and cut and cover tunnels and approach rock cuttings. (Construction Value HK\$5 Billion.) Detailed assessment on impacts of existing structures from underground and deep excavations in a variety of ground conditions.
- KCRC West Rail DB-350. Project & Design Manager for the design and build tender of the 5.5km, Tai Lam Tunnel (Contract Value HK\$1.9 Billion (US\$ 250M)).
- West Rail TS-300. Section Design Manager for the 5.5km rock tunnel through Tai Lam Country Park, responsible for coordinating all aspects of the design inputs including tunnel, site investigation, geotechnical, operational, traffic, E&M and civils teams. Also Design and Project Manager for D&B tender design
- MTRC Tsung Kwan O Contract 611. Project & Design Manager for the design and build tender of the 5km tunnel complex in mixed ground conditions. (Construction Value HK\$700M.)
- Route 9 Nam Wan Tunnel. Tunnels Team Leader responsible for the detailed feasibility study including site investigation planning and implementation for the proposed twin three lane highway tunnel through Tsing Yi.
- West Rail TS-100. Tunnel Design Team Leader for the 550m Tam Mei Tunnel in mixed ground conditions including site investigation specification and implementation.
- West Rail Kwai Tsing Tunnel Technical design inputs and coordination of design of 1.2 km Tsing Tsuen Tunnel, in variable ground conditions and close proximity structures in an urban environment.
- Discovery Bay Tunnel, Lantau. Review of temporary support requirements to be installed during construction of a 14m diameter rock tunnel. Appraisal of ground conditions and design review during construction.
- Quarry Bay Extension. Preparation of tender submission for tunnel and station improvement works with the development of innovative design and construction solutions to envisaged problems.

**1994 -1996 - GEO-ENGINEERING, RESIDENT GEOTECHNICAL ENGINEER, TING KAU BRIDGE AND APPROACH VIADUCTS, HONG KONG**

- Mr MacKean was responsible for the geotechnical aspects of the construction of the Ting Kau Bridge, a HK\$1.73 billion, 1.1km long cable stayed structure, and the associated approach viaducts and substantial earthworks, from site investigation through to completion of construction.

The approach structures were founded on over 100 large diameter hand dug piles with up to 5m rock sockets some situated in 45 degree slopes, requiring detailed evaluation and design review during construction. The three towers of the main bridge were founded on two pad footings (4000m<sup>3</sup> each) and a piled raft on 52 bored cast in situ 2.3m diameter piles. Ship protection structures were constructed around each of the towers, requiring underwater blasting, dredging, reclamation (including wick drains, vibro compaction, CPTs and geotechnical monitoring), seawall and pre-cast cofferdam construction. Cutting back (blasting) of existing 70m high rock slopes adjacent to a live motorway was also completed and stabilised.



## 1990 - 1994 - ENGINEERING GEOLOGIST, ENGINEERING GEOLOGY LTD

### Rock Engineering

- Jersey Storage Cavern. Detailed rock mass characterisation, preparation of sectional models, and design of rock anchor support systems for the 25,000m<sup>3</sup> storage cavern (17.5m span) and associated tunnels. (In association with Geo-Engineering.)
- Motokea, Papua New Guinea. Review of stability of a proposed dry dock with associated rock slopes.
- Quarry, North Wales. Analysis of cause of slope instability relating to existence of mine workings.
- Wiltshire. Structural geological survey of an existing mine and extensive underground storage area.
- Guildford, Surrey. Logging of a chalk cutting and tunnels and supervision of rock anchor installation.
- M4, Wales. Advice to a contractor on the likely rippability conditions to be encountered during the excavation of a proposed 2km cutting within carboniferous sandstone.
- Channel Tunnel. Engineering Geologist working on certain geotechnical aspects of the excavation including, in particular, fracture spacing, permeability and predicted water inflow.
- Supervision of ground investigation for Crossrail.

Robert was also involved with a number of projects with technical inputs comprising, **Geotechnical Engineering, Materials Assessment and Dredging (with Dredging Research Ltd.), Hydrogeological and Environmental Studies**

## 1987 - 1989 - GEOLOGIST, SCOTT WILSON KIRKPATRICK

At Scott Wilson Kirkpatrick and Partners he worked on many site investigations carried out on behalf of the Property Services Agency which included studies for low and high rise developments, earthworks and retaining wall design and remedial works for slope instability.

### PUBLICATIONS

MacKean, R.A.N. and Rosenbaum, M.S. Geostatistical Characterisation of the SPT Proceedings of the 6<sup>th</sup> International IAEG Congress, Rotterdam, 1990.

Mcfear-Smith, I., MacKean, R.A.N. and Woldmo, O. Water Inflows in Bored Tunnels Driven in Hong Kong: Prediction, Construction Issues and Control Measures. Proceedings of the International Conference on Urban Ground Engineering, Hong Kong, 1998.

Sharp, J.C. and MacKean, R.A.N. Rock Slope Design - A Review of Current Practice. Proceedings of the IMM Conference on Engineering Geology, Hong Kong, 2000.

Sharp, J. C, Bandis, S.C., MacKean, R.A.N. Evaluation of design concepts for an urban underground railway station : Engineering assessment of design analysis. UDEC Symposium - Bochum 2004/