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The grittiness of soils, the structural complexities of rocks........

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Synopsis: My contribution to this volume reflects my debt of gratitude to selected mentors, selected from many, who have shared their powers of observation and the distillation of their experience, concerning the practical behaviour of soils and rocks. They have emphasized the context in which each situation needs to be appraised as a part of geotechnical design. I make no claim to propriety of my 'mentors', indeed, I well know that each has influenced many others privileged to share their friendship, influence and encouragement.

The second world war had ended and those of us who had been far from home returned to an unfamiliar world. Life in Britain in early 1947 was figuratively and literally grey and cold, recalled as being sunless for more than three months. It was then, as a newly recruited railway engineer myself, that I first encountered A.H. Toms. A civil engineer working with the Southern Railway, he had been selected to attend a course in 1938 at the Building Research Station run by Len Cooling and returned to the railway, initially to attend to stability problems at Sevenoaks and Folkestone Warren, subsequently to be appointed as Research Assistant (titles in those days did not reflect the level of responsibility) to the Chief Civil Engineering, which included the setting up of a soil mechanics department. By his experience and character, Toms maintained a direct, practical approach to every problem, applying simple theory to establish principles for dealing with a number of traditional geotechnical problems of the railway, hitherto attacked in an inconsistent pragmatic fashion. The man-made features of unstable track formations and railway embankments, for example, present complex and variable problems.

The railway line between Dover and Folkestone on the southeast coast of England passes through a length of about 3 kilometers of unstable undercliff, Folkeston Warren. In 1939 Toms undertook an investigation of a landslide to the west end of the Warren which was threatening to extend towards the east and affect the railway line. By 1948, creeping movement of the ground had indeed extended to involve an area of many hectares. I was engaged for two years investigating this instability, under the direction of Toms, and in contributing to the associated remedial work. Toms was a most appropriate, knowledgeable and kindly mentor for my first encounter with a practical site investigation of rather peculiar variety. For example: local history threw light on the timing of landslides in relation to season and rainfall; paleontology, largely the identification of representative ammonites, allowed some reconstruction of the history of these past landslides. At a time of post-war shortages, simplicity and improvisation were required, applied to the detection of ground movements as elsewhere. In consequence, crude slip indicators were installed down boreholes and along the drainage adits, which traversed the undercliff at intervals, these latter making use of copper signalling wire reeved on pulleys from end to end. [as a footnote, when movement resumed further to the east of previous activity in 1972, these latter indicators, although apparently forgotten by the authorities for twenty years, located the position of the slip surface as originally intended].

Toms suffered poor health, belied by his buoyant disposition, and his potential was underrated by the railway, nationalised from 1947. His unit was housed for many years in a house of Victorian age, in the vicinity of Waterloo Station, approached as I recall somewhat in the manner of Jacques Tati's lodgings in the film 'Mon Oncle'. When he died at the age of 60, in 1967, Toms left a legacy of understanding of clay weakened by dynamic stress, of the composite structure of embankments filled from time to time to compensate for creeping movement over many decades, of the behaviour of uncompacted chalk, and the definition of many other types of geotechnical problem affecting an old-established railway system. He also left a small loyal team he had trained to keep their feet on, or occasionally in the ground. I soon left the railway but we maintained contact and I recall our friendship with much pleasure and try to practice his example of an observation-based approach to any problem prior to defining how to investigate it and to theorize.

My second recorded mentor was H.J.B. (later Sri Harold) Harding, an essentially practically- minded engineer, one time Director of John Mowlem and initiator of their subsidiary Soil Mechanics Ltd. Harding, at the top of his profession, maintained a respect for all who contributed to a task, valuing the practical skills that needed to complement analysis and management. He recognized his own limitations in mathematical analysis but showed discernment in those he trusted to complement his own innovative and practical nature. He was well read, a witty and eloquent speaker, with notable contempt for pomposity and arrogance in others. He recognized the need, in a professional world that had been something of a gerontocracy, to encourage the younger engineers who brought new ideas and new understanding to the debate.

I recall a meeting with him to discuss the basis for design of an early use of tunnel rock-bolts for the support of a large telecommunication tunnel at Oban in Scotland. Soon thereafter, responsible for stabilizing a coastal landslide which threatened a town center, I faced a critical situation which led to a, predictably confrontational, meeting with the contractor's insurance assessor. To my great delight, this turned out to be Harold Harding. Disposing with the fundamental contractual issue immediately, we spent our time in determining the best way to undertake the essential urgent remedial work, adopting in so doing the use of a concrete displacer, probably the first (and last?) time this piece of tunneling plant current at the time was used in coastal engineering.

But our longest association concerned the Channel Tunnel for which project he, with Réné Malcor, represented the Channel Tunnel Study

Group (CTSG). In 1958-59, I led the British team in a study, which included a marine site investigation, on a minute budget, using a drilling vessel which Harold Harding, in an earlier capacity, had originally commissioned as such. Harold injected much wisdom and common sense into this Franco-British occasion, which might so easily have become derailed. In 1964-65, the CTSG once more directed studies on a broader scale but this time financed and 'supervised' by an unwieldy Franco-British *Commission de Surveillance,* which added greatly to the cost of the work without noticeable compensating contributions. This was a testing time for all those concerned with best value for money for such a set of studies, necessitating rapid decisions and the freedom to manage a considerable fleet of drilling and surveying craft and platforms. Without Harding's steadying hand, the event would probably have foundered in claims, counter-claims and recriminations. It is curious how often Government appointed bodies, directing others, appear to manufacture problems whose only objective seems to be *amour propre*, whose cost falls upon the taxpayer. As the Channel Tunnel project subsequently evolved in violent switches of policy as to the funding of the project, Harding continued to take much interest. In a conversation shortly before his death in 1986, he expressed much satisfaction that the project was a last approved to proceed. He would have been less pleased by the costly dilution of good engineering by poor management.

In 1971, at the age of 71, he was elected the first Chairman of the British Tunnelling Society, setting the example for lively informality which has encouraged young and old, the practical and the academic, fruitfully to exchange views over the intervening years.

Much of the eighty kilometers of the Orange-Fish Tunnel lies in mud-rocks, lending itself to the application of rock-bolts and sprayed concrete for support. Limitations of direct experience and the wish to apply best practice, looked towards recent achievements in the Snowy Mountains Hydroelectric Project in New South Wales. The consequence was the appointment as consultant of Tom (T.A.) Lang, who had served as Assistant Commissioner, effectively Chief Engineer for the 'Snowy'. Tom had contributed much to the understanding of the functioning of 'interactive' support, based on observation of practical behaviour and experiment. What could be more practical, for example, than his celebrated demonstration of the 'arching' benefits of rock-bolting by means of an upturned bucket of rock fragments prestressed between end-plate and top washer. He brought much insight from his experience, making major contributions to a rational method of design developed largely by B.C. Kidd and adopted for the Orange-Fish Tunnel with great economy and success. A particular feature concerned the way of dealing effectively with dilating rocks without overstressing the bolts. It was only later that those concerned realized the extent to which a number of the common principles of this pioneering work were shared with the New Austrian Tunneling Method – if not the claimants' detailed philosophy.

Later, in 1974, B.C. Kidd and I were together in Denver for the ISRM Congress. Tom Lang organized an interesting visit to the Straight Creek (later the Eisenhower) Tunnel followed by a meeting with the designers of the second tunnel during which we discussed means of avoiding the extraordinary problems of the first tunnel. This was an exhilarating occasion with the greatest freedom of access to information, such as is only occasionally possible, much infused and enthused by Tom Lang's personality.

The final member of my geotechnical team of mentors is Robert Legget who needs no introduction to this community, but who needs to be recalled as philosopher, historian, biographer as well as engineering geologist and geotechnical engineer. Robert had an unique ability to see each object of his many interests in the round. When he began to enquire why a geotechnical project had been undertaken in a particular way, he set himself the task of exploring history, the nature of the individuals who had made the major contributions and the state of knowledge at the time of the related science and engineering. The result was a remarkably 'three-dimensional' account of the project concerned, usually with lessons to be learned for application elsewhere. For example, his study of the construction of the Rideau Canal entailed a monograph on its engineer, Colonal By, the early days of By Town (Ottawa) and an explanation as to why this remarkable engineer returned to Britain to face interrogation and ignominy in the place of the recognition he deserved. This is a cautionary tale for engineers concerning faith in politicians and the desirability of recording the basis of knowledge on which engineering decisions were made- this is a very useful repellant to the wise-after-the-event lawyer to whom, once the nature of the defect is explained, finds an error of judgment, prior to the event, so obviously impeachable.

Robert worked for a period (1925-29) with my Firm, Halcrow, prior to emigration to Canada where, after much varied experience in practice and academia, he was appointed Director of Building Research within the National Research Council. I have unfortunately lent and lost one product of this period, a published Paper entitled 'On the noise level at cocktail parties'. He was indeed a man of great versatility, humility, humanity and perception. He was indefatigable, active up to his death at the age of 89 in 1994, maintaining very many friendships who derived much benefit from his advice and views based on so much accumulation and distillation of knowledge and experience.

One common feature of those I mention above has been their dependence on observation, a trained sense of seeing more than is immediately obvious and in drawing together, from the composition of different pieces of data, an overall picture from which to derive conclusions of geotechnical significance. This is a vital faculty too easily lost by dependence on over-simplification in order to satisfy the input data of a computer program. Quality assurance, which confines attention to foreseen problems, is no substitute for recognizing incipient problems that were not suspected. In fact it tends, by over-confidence, to reduce dependence on observation. As Sir Harold Harding has put it so pithily 'The engineer must always be prepared to be surprised but never astonished!'