KARL TERZAGHI, 1883–1963

Thoughts occasioned by the centenary of his birth

R. B. PECK

On the centenary of the birth of Karl Terzaghi, now almost a legend to the young workers in geotechnics, there can be no better way to catch the essence of the man and his work than to read the memorial, in the March 1964 issue of *Géotechnique*, written by the man who knew him best—his student, friend and colleague, Arthur Casagrande. Casagrande commented on Terzaghi's interest, in the last years of his life, in protecting the young generation of soils engineers from pitfalls, among them being reliance on soil mechanics theory without adequate practical experience.

Terzaghi understood from the beginning that a sound theoretical basis is essential to progress in subsurface engineering, and was himself responsible for providing much of that basis. The scepticism greeting his early theories led him to defend them vigorously and even to go on the offensive in advocating their acceptance. Yet no less essential, he held, were knowledge of the physical properties of the soils to which the theories were applied and, above all, testing the predictions of theory against actual field performance. He feared that when pure theoreticians discovered soil mechanics they would do it irreparable harm, because they would find it easier and more to their liking to continue to elaborate their theories than to pursue the slow, painful and often frustrating course of critically evaluating the theories against the hard realities of observed behaviour in the field.

Arthur Casagrande, only a few months before his death in 1981, wrote:

> 'How clearly Karl T. had foreseen more than 50 years ago the risks to sound development of soil mechanics from mathematicians! It was on a hot summer evening in 1926, during our daily walk around the Mirror Pool facing Lincoln Memorial, when Karl explained to me this risk; and then summed it up with one of his characteristic, humorous comments: "Mathematicians are useful animals who should be kept in a golden cage and fed problems judiciously."'

If Terzaghi feared the influence of untested theory at a time when theoretical calculations were laboriously made with few aids beyond slide rules and tables of logarithms, and when solving even half a dozen simultaneous equations was a major investment of time, what would he have thought of our modern age of electronic computation? He was aware of the early developments in this field; indeed, his office at Harvard was only a stone's throw from Howard Aiken's laboratory, regarded by many as the birthplace of the modern computer, but he could hardly have foreseen the ensuing revolution in our ability to calculate. He could not have foreseen either the power or the widespread adoption of such procedures as the finite-element method, in which the ability to analyse even the most complex problems is often limited, if at all, only by the cost of computer time. What would be his reactions to this development, and to concurrent equally spectacular advances in instrumentation, data processing, and automated soil testing?

He would surely, for example, have welcomed the ability of the finite-element method to produce numerical results taking account of complex geometrics, realistic stress–strain relations, stage construction, and anisotropic conditions. He would have appreciated the insights afforded by parametric studies. He would have applauded such investigations as those in which field observations and finite-element calculations have been used hand-in-hand to further our understanding of braced cuts. He would most certainly have made extensive use of the new tools and of the specialists capable of their best utilization. But he would have sensed once more a danger, especially to the young engineer, in possessing such powerful means of computation, and he would surely have spoken out again against a blind or blinding faith in theory.

There is ample evidence that this faith is no less prevalent today than in the past; quite the contrary. Entire conferences are devoted to 'geotechnical' computational procedures. The participating specialists have on occasion been annoyed when a practitioner has challenged an assertion such as 'the backbone of earth-dam design is stability analysis'. Are these specialists becoming a dangerous subculture that would replace by computer printouts the artistry in earth-dam design exemplified by Terzaghi's writings on Mission, Sasumua, Vermilion, or—especially—Cheakamus Dam?

Once again, comments by Arthur Casagrande, in a letter following the Moscow Conference in

Karl Terzaghi

1975, are appropriate:

> 'With the proliferation of mathematical methods, it seems to me that it is simply not possible for the great majority of engineers to be proficient in all tools. It is inevitable that most men become one-sided as a result of such specialization and the years of study required to become an expert in even one of the tools. Therefore, what we need is well co-ordinated teamwork of men who really understand soils and have a great deal of practical experience in applied soil mechanics with others who have developed specialized skill in the use of modern mathematical tools. Unfortunately those who are so specialized hardly ever possess an intimate knowledge of soil properties and extensive practical experience in applied soil mechanics, and they do not realize their serious limitation but consider themselves self-sufficient'.

Terzaghi ended his James Forrest Lecture, which in 1939 provided the stimulus for the remarkable developments in soil mechanics in the UK during the ensuing years, with a quotation and an admonition that he would surely consider no less needed today, although he might replace the word 'formulas' by 'computer programs'.

> '... I cannot help feeling deeply concerned about the self-confidence inspired in many members of the incoming generation of engineers by our knowledge, because ... 'There is a tendency among the young and inexperienced to put blind faith in formulas, forgetting that most of them are based upon premises which are not accurately reproduced in practice, and which, in any case, are frequently unable to take into account collateral disturbances, which only observation and experience can foresee, and common sense provide against.'

Terzaghi was quoting a remark made in 1893; he went on to close with:

> '... Today, ... these golden words should be framed, to adorn the wall of every room in which research in soil mechanics is carried on. To accomplish its mission in engineering, science must be assigned the role of a partner and not that of a master.'