SOIL MECHANICS AND FOUNDATION ENGINEERING

FOURTH INTERNATIONAL CONFERENCE

PERHAPS the most outstanding development in modern civil engineering practice has been the remarkable growth in the science of soil mechanics during the past thirty years. The publication in 1925 by Prof. Karl Terzaghi of his book "Erdbaumechanik auf Bodenphysikalischer Grundlage", in which he described his researches into the consolidation and shear strength of soil, is generally regarded as marking the beginning of the scientific study of soil as material of engineering interest. There followed a period of increasing interest in the subject, evidenced in Great Britain by the establishment in 1933 of a soil mechanics laboratory at the Building Research Station at Watford, Hertfordshire.

The year 1936 marked an important stage in the development of this new science, since in that year the first international conference was held at Harvard University, and this led to the formation of the International Society of Soil Mechanics and Foundation Engineering, with Prof. Terzaghi as the first president.

Since the end of the Second World War the International Society has gone from strength to strength, and there are now thirty countries represented in the Society as well as many private members from other countries. Following successful conferences at Rotterdam in 1948 and at Zürich in 1953, the largest and most successful, the fourth, took place in London during August 12–24 at the Institution of Civil Engineers, at which some 750 delegates were present.

Following the opening of the Conference by Sir Arthur Whitaker, president of the Institution of Civil Engineers, Prof. Terzaghi delivered an address to the Conference in which he developed the theme of his opening speech to the Zürich Conference, namely, that the application of soil mechanics to civil engineering problems, in spite of the advances in the knowledge of the properties of soils, will never be a matter of precision because of the variability in the properties of soils occurring in most strata, and must ultimately depend upon the skill and imagination of the engineer.

Some 189 papers were submitted, and in the light of experience gained at previous conferences these were placed into six divisions: (1) soil properties and their measurements; (2) techniques of field measurement and sampling; (3) foundations of structures; (4) roads, runways and rail-tracks; (5) earth pressure on structures and tunnels; (6) earth dams, slopes and open excavations.

There were nine technical sessions each of three hours duration, two being devoted to the subject-matter of division 1 and three to that of division 3, in view of their especial interest. Each session followed a similar course in which a general reporter opened the proceedings by summarizing the main conclusions he had drawn from reading the papers contributed to the particular division with which he was concerned, and he was followed by individual contributors to the discussion of the papers by members of the Conference. On the whole, the discussions were of a high standard and very stimulating, as was demonstrated by the high level of interest maintained by members throughout the week and a half of what must be admitted to have been a somewhat exhausting programme.

It was abundantly clear from the Conference that soil mechanics has a major part to play in civil engineering developments throughout the world, and it is natural that a considerable growth of interest in the subject is taking place in regions where there are large areas calling for development, as, for example, in Canada and the U.S.S.R.

The great increase in the amount of construction of high multi-storied buildings and other large structures has resulted in a corresponding growth of interest in the design of the foundations to carry heavy loads. Useful progress was reported in the development of methods of estimating the ultimate bearing capacity of foundations, but especial interest was shown in the problem of making accurate estimates of the settlement of structures founded on clays and other compressible soils. It appears that in spite of the many assumptions made in the method of estimating settlements based on Terzaghi's theory of consolidation, reasonably satisfactory agreement between the calculated and actual settlements is usually obtained for normally and lightly over-consolidated clays; heavily over-consolidated clays have been shown to need a special approach. A disappointment was the absence of any significant advance in obtaining a better understanding of secondary consolidation, which is the compression phase that occurs after the dissipation of the excess pressure of pore-water created by loading the soil.

In spite of improvements in the theoretical treatment of the bearing capacity of soils, the evidence from several papers indicated that serious discrepancies can occur between the actual and calculated values. This renders important the problem of how best to introduce a factor of safety into stability analyses. It emerged that there is now general agreement that the most rational method is to use a reduced value for the shear strength of the soil.

On the subject of pile foundations, practical evidence suggests that considerable confidence can now be placed in the methods used for estimating the load capacity of piles driven through soft soils to a firm granular stratum and of piles embedded in sand, but it appears that loaded piles embedded in soft clays are liable to significant settlements over long periods of time.

Another important application of soil mechanics is to the stability of slopes. This subject embraces natural slopes, which may be affected by sudden landslides or slow creep, excavated slopes such as cuttings for railways, roads and canals, and embankments, of which the most important example is earth dams.

Members of the Conference were given a graphical reminder of the devastation that can follow from a large landslide by a description by Mr. Fellenius of the great slides on the Gotha River in Sweden. Scientific studies are now frequently made of such landslides with the object of understanding more precisely the mechanics of the process. Of especial interest was the explanation by Prof. A. W. Skempton

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(Imperial College of Science and Technology, London) of the reasons why London clay assumes a natural slope of 10 deg.

It was noted that very little effort is being devoted to the problem of the stability of excavated slopes. It appears that such slopes are often initially cut at a much steeper angle than is satisfactory for stability, and where large and costly cuttings are required, as, for example, for modern highways, a greater application of the principles of soil mechanics was advocated.

A session of the Conference was devoted to a discussion of earth pressures which determine the stresses acting, for example, on the linings of tunnels and on sheet piling and other earth-retaining structures. It is now recognized that in practice some yield of the structure almost invariably takes place, and the problem is then to make a reliable estimate of the distribution of stresses on structures in terms of this yield. Useful progress on this problem was reported in respect of both sheet piling and tunnels.

The rapid growth of traffic on the roads and the increased weight of aircraft have resulted in the need for thicker and stronger foundations for road and airfield pavements. This has rendered important the need for improved methods of pavement design in order that the most economical approach may be determined with some precision. Although the papers contributed to the Conference were scarcely representative of present thinking on this subject, it appears that reliance is mainly placed on empirical methods of design in which the estimated thickness of pavement is related for particular traffic conditions to the bearing strength of the soil measured by some form of penetration or loaded plate test. However, a trend was noted towards thinking in terms of a design method based on the moduli of deformation of the soil and pavement materials.

An understanding of the factors affecting the moisture conditions in soils under pavements is important because the moisture content largely governs the strength of the soil and hence the design of the pavements. While a satisfactory solution of this problem for humid climates has been developed in terms of the suction properties of the soil, it emerged that the part played by vapour transfer under more arid climatic conditions is not yet fully understood.

Quite apart from the consideration given to the physical properties of soil during the discussion of papers presented in division 1, the Conference was repeatedly brought back, during the sessions devoted to the more practical problems of foundation engineering, to the need for a better understanding of the fundamental factors governing these properties. There is now general recognition of the need to express shear strength in terms of effective stresses, and of the importance of making pore water pressure measurements both in laboratory tests and in field studies. These conclusions are, however, of principal value in their practical application to analyses of stability problems and do not help to any great extent in understanding the bases of soil strength.

Perhaps the most encouraging development at this Conference was the emergence of a body of support for the concept that many of the observed shear properties of soils can be satisfactorily explained in terms of internal normal stresses resulting from tensions in the pore water system. It was suggested that the development of this concept may well lead to the shear strength of soil being expressed in terms of a dimensionless coefficient of friction. Papers to the Conference also indicated useful advances in attempts to explain soil properties in terms of colloid chemistry and surface physics. Perhaps it is not too much to hope that by the time the next Conference is held a satisfactory hypothesis will have been developed that explains the part played by tensions in the soil water system and at the same time relates these tensions to the surface forces resulting from the interaction of clay minerals and water.

At the closing session of the Conference, members learnt with deep regret that Prof. Terzaghi had decided to relinquish the presidency of the International Society. The new president is Prof. A. W. Skempton, professor of civil engineering at the Imperial College of Science and Technology, London. It was also learnt that the offices of the Executive Committee had been transferred from Harvard University to the Institution of Civil Engineers in London, with Mr. A. Banister as secretary to the Committee. Paris has been selected as the meeting place for the next international conference.

During the Conference a number of technical visits were arranged to government, university and commercial soil mechanics laboratories and to sites of civil engineering interest. Receptions were held at the Tate Gallery, at the invitation of the chairman and members of the Public Works and Municipal Services Congress and Exhibition Council, and at the Hurlingham Club, and the Conference concluded with a banquet held at Grosvenor House. Following the Conference, many members joined short trips to various parts of the country to see works of civil engineering interest. D. J. Maclean

GAS CHROMATOGRAPHY

An International Symposium on Gas Chromatography, sponsored by the Analysis Instrumentation Division of the Instrument Society of America, was held at the Kellogg Center for Continuing Education, East Lansing, Michigan, during August 28–30. H. J. Noebels (Beckman Instruments) was general chairman, and the programme was organized by V. J. Coates (Perkin-Elmer Corporation). The meeting was attended by about 350 people. Formal sessions were held in the mornings and evenings, leaving the afternoons free for informal discussions by small groups. This proved to be a very happy arrangement, as it allowed those with special interests to discuss fine points at length without holding up the main proceedings; I remember in particular a very lively triangular discussion between M. J. E. Golay, A. J. P. Martin and A. I. M. Keulemans on the usefulness of the theoretical plate concept. The formal meetings consisted of invited lectures, followed by a series of short contributed papers.

A large number of papers were concerned with the application of gas chromatography to specific analytical problems, such as arise in connexion with gasolines, ester-type plasticizers, chlorofluorohydrocarbons, glycols and piperazines. Many of the speakers commented on the savings in time and money which the new technique had brought to their companies. Other papers were devoted to detailed

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