

security, unless full advantage is taken of the services they are able to render. A satisfactory formula for accomplishing this purpose has not yet been established.

The preceding suggestions are based on my personal experiences and observations, the scope of which is inevitably limited. Therefore, other consultants and engineering firms employing consultants could render a valuable service to the engineering profession by presenting in the discussions to this paper some of their experiences and opinions concerning the relationship between consultants and clients.

DISCUSSION

BY ARTHUR CASAGRANDE,* *Member*

A frank discussion of the use and abuse of consultants in earthwork and foundation engineering by engineers with broad experience was long overdue. It is, indeed, fortunate that Professor Terzaghi has undertaken the task to initiate and encourage such a discussion because, more than anyone else, he combines all the qualifications needed for pointing out clearly where the troubles lie and how they can be overcome.

The problem is complicated not only because of the great variety of technical questions on which the advice of a consultant is sought, but because many aspects of "human engineering" are involved. The most effective approach would be by a frank discussion of a number of typical case records. Unfortunately, that cannot be done without stepping hard on somebody's toes or kicking some other delicate part of the human anatomy. I regret to admit that I am responsible for having counseled Professor Terzaghi to delete some exceedingly instructive case histories from his original manuscript.

The situation is similar to the publication of settlement records and other observations on structures which have not performed satisfactorily. Progress in earthwork and foundation engineering would have been much more rapid if publication of such data would be the rule rather than the exception.

Professor Terzaghi has made it quite clear that principal causes of trouble are (1) the fact that the actual subsoil conditions cannot be known exactly during the design stage and that appropriate changes

*Professor of Soil Mechanics and Foundation Engineering, Harvard University.

in design must be made as construction proceeds, and (2) the changes that the construction department will make or authorize without notifying the designers, or the "discrete departures from the specifications" by contractors. Professor Terzaghi points out that the principal requirement for solving such difficulties is a competent soil mechanics department that creates the liaison between the design and the construction departments, and that is empowered with sufficient authority. Most of the large construction organizations in this country which are engaged in earthwork and foundation engineering maintain such soil mechanics departments. They include the Corps of Engineers, the Bureau of Reclamation and many State Highway Departments, to name just a few of those doing excellent work in applied soil mechanics: California, Illinois, Indiana, New York and Texas. I regret that the Department of Public Works of Massachusetts is an example that lacks such a liaison between the design and construction departments. The result of such lack of cooperation culminated last year in a case that has made the newspaper headlines, and which is a good example of a consultant being made the scapegoat for mistakes by a contractor which are allowed to pass because of the lack of soils engineers who form the necessary link between design and construction.

It would seem that if a consultant values his reputation higher than public service, he cannot afford to work for those State and Municipal engineering organizations which are subject to excessive political pressure. But if no competent professional men were willing to risk being made the scapegoat, we would certainly not find such men in public service, and politicians would run everything.

The instance referred to above was made worse by the fact that field inspection was not part of the design contract. Therefore, the firm that prepared the design had no way of checking whether construction was carried out in accordance with the design. In connection with this question, attention is called to an excellent editorial on page 128 of the November 21, 1957 issue of *Engineering News-Record* that criticises the practice of "design without designer inspection."

When discussing the relationship between the engineering firms and special consultants they employ, there are certainly instances when the firm may have a right to make the final decision. The senior partner of a firm once made this comment: "After all, we are the ones who carry the responsibility, not our consultants. Besides,

whenever we employ more than one consultant they usually disagree among themselves and then it is up to us, the designers, to make up our minds."

It would certainly seem logical that the division of responsibility should be clearly defined when consultants are employed. But even that is simpler said than done, because in many instances the responsibility of the consultant grows and changes as the job progresses.

Strictly speaking, every consultant, or board of consultants, is limited in the scope of their duties. However, a consultant should be free to question any aspects of a project, even outside the defined scope, if he believes that it may affect the safety of the project. E.g., on a number of dam projects I have questioned the freeboard because I did not trust the hydrologic data. On several projects, as a result of my insistence, a differential of several feet in freeboard was established between the main dam and one or several saddle dams, so that the saddle dams would be overtopped first, which would result in relatively minor damage. In other words, these saddle dams may become emergency spillways, although this may not be officially recorded in order to prevent protests from those who would suffer from the failure of such a saddle dam.

In conclusion, I should like to repeat my belief that there are too many variables involved in the relationships between Consultants, Clients and Contractors to permit hard and fast rules in order to assure that consultants will be used to the best interest of a project. But a careful study and re-reading of Professor Terzaghi's paper by all concerned will do much to develop a better awareness and judgment of the ramifications of the relationships between these three C's, of the conflicts that may arise from a lack of clarity in the definition of the duties of a consultant when he is employed, and of the paramount importance of continuous inspection of earthwork and foundation projects by competent soils engineers who form the liaison between the construction job, the design office and the consultant.