tions were readily accessible. This procedure, of course, involved the abandonment of a substantial sum already spent on the plant construction and required prolonged and detailed discussions of the reasons for abandonment, particularly since "a similar plant had been built on another site in another section of the country on 50 ft wooden piles and had proved to be satisfactory." We are indebted to Dr. Terzaghi for his assistance as our consultant in this case and the added weight of his experience and confirming testimony which resulted in the mill being moved to a safe location.

In closing this discussion, it is a pleasure to pay tribute to Dr. Karl Terzaghi for his invaluable assistance as consultant to our organization on many complex foundation problems over the past 30 years.

Discussion

By D. J. Bleifuss*

I have read Mr. Terzaghi's paper with considerable interest; the subject is one which should be given a good deal of attention. I must start my discussion by disagreeing with him when he says his personal experiences and observations are limited; the scope of his experience is about as unlimited as it is possible for any one man's to be. There are few consultants as well qualified to discuss this subject.

He is quite right in saying that consultants are often not used to the best advantage. A client may not employ a consultant at all, when he really needs one badly. A client may select the wrong consultant. A client may make the wrong arrangement with the right consultant.

It is a curious fact that many laymen consider themselves qualified to criticise an engineer, or to do their own engineering. Time and education will take care of this, as the public comes more and more to realize that this civilization of ours is based on the work of the engineer. The roads we travel on; the cars we ride in; the machinery we use; the energy to drive our machinery; our communication systems; our water systems; they are all based on the work of the engineer.

A client may select the wrong consultant. To many people, an engineer is an engineer; they make no distinction between bridge,

*Bleifuss, Hostetter & Associates, Consulting Engineers, Sacramento, California.

hydroelectric, sanitary, and other engineers. The same people would not dream of employing an obstetrician when they really need a skin specialist. Reputable consultants will not accept employment in a field where they feel they cannot do the best work. A consultant may be hopelessly incompetent; fortunately, there are very few of this class and they usually do not last long. A great name and reputation are no good guide in selection, which should be based on only one consideration, i.e., what the consultant has actually done in the field where his advice is being sought.

A client may make the wrong arrangement with a consultant. Wishing to save money, he may limit the consultant's employment to one particular phase of the work, such as preliminary layout and gathering data, design, or the supervision of construction. In the first two cases, there may be no "follow through," in the last case the consultant may be called on to supervise the construction of something he knows could be improved or is radically wrong. If limited to preliminary layout and gathering data, the consultant has no control over detailed design or the field changes inevitably necessary as construction develops new information. If limited to detail design, he may find his data insufficient (very common), that it has been misinterpreted, or that the preliminary layout is wrong. He will have no assurance that his careful design will be carried out, and, again, no control over field changes.

In such cases, if trouble develops, all the engineering on the job gets tarred with the same brush, regardless as to where the fault specifically lies. It is difficult to see what can be done about this, since a consultant cannot very well refuse employment on the grounds he is not being asked to do enough.

I wish to cite a few illustrations:

A. A dam site had been chosen and investigated. On being called upon to make a preliminary design and estimate, I found that a much better site close by had been disregarded.

B. An earthfill dam project—it had been reported that pervious material was plentiful, and impervious material scarce. When called upon for detailed design, we wished to check these data in the field, but the client insisted this was unnecessary and that he placed implicit reliance on his own engineers. The dam was designed accordingly. Upon personal investigation later, I found the data wrong; impervious material was plentiful, and pervious material scarce. The

contractor had already started work, but the dam had to be redesigned. Then the client protested the extra expense.

C. We designed an earthfill dam, but the client insisted on supervising construction with his own forces; we were to have nothing to do with it. On casually visiting the dam during construction, I found to my horror, that where we had specified sand and gravel, silt was being placed, and very wet silt at that. It was merely the client's and our own good luck that we caught this in time.

D. We designed a concrete dam, but were to have nothing to do with supervision of construction. However, when placing of concrete was started, I looked at the first test reports, and found the concrete was not up to specifications. Although it was none of my business, I protested vigorously and the condition was corrected.

A consultant's relationship with a contractor may be of two kinds, the contractor may be his client, or the consultant may be the owner client's representative. Many contractors consider the engineer as an unmitigated nuisance and evil and think they could very well get along without him; some contractors have progressed to the point where they admit the engineer is a necessary evil; the best contractors cooperate whole-heartedly with the engineer. Quite often, the contractor's employees, regardless of his attitude, have a mistaken idea of loyalty, and think that by cutting corners, they are serving the contractor's best interest. Or they have not the slightest notion as to the reason why certain things must be done in a certain fashion, and regard any requirement which may interfere with speed and production as quite unnecessary. A foreman who two years ago was a laborer, will argue with an engineer of thirty years' experience. I may cite one case: a lift of concrete had been placed, with dowel steel projecting upward from its surface to tie in the next lift. As soon as the concrete had attained its set and could be walked on without footprints being left, the contractor's men swarmed over it, erecting forms for the next lift. The dowel steel was pushed around, with the result that each rod was soon standing in a hole, with no bond at all for perhaps twelve inches below the surface. It was a rush job, and my protest was regarded as unreasonable interference with progress. Another case: transmission tower foundations had been placed as much as three inches out of line and guide; steel towers erected on them were in consequence very much distorted, and it was necessary to take down the towers, dig up the foundations and start over. A totally unwarranted interference with progress.

Our trouble with an engineer's performance is this: if his job is well done, the work goes smoothly, and client and contractor alike are apt to consider that the money spent on engineering has been wasted; if the work does not go smoothly, they are apt to place the blame on incompetent engineering.

A consultant may better his relations with a contractor by adequate explanations; most men really like to know why they must do thus and so. A very fundamental thing: a consultant must design with an eye on what construction methods are to be used, and materials available.

A client employs a consultant because he thinks the consultant knows more than he does, and he wishes the benefit of superior knowledge. It is only common sense to make an arrangement which will insure he does get such benefit. He wishes to be assured the project is safe, that it will function properly, and be economically designed both as to first and annual costs.

Many consultants are specialists in rather narrow fields, and it would be quite useless to employ them in broader fields, and expect them to perform well. Others are more general in their knowledge, and they should be employed to coordinate the work of the specialists. I can best illustrate this in the hydroelectric field, with which I am familiar. A hydroelectric project should have an engineer of broad experience in this field in over-all charge. He does not need to be an expert in all the detailed phases of his work, but he must be able to know when he needs a specialist's help; he must be willing to ask for it; and be able to use it when he gets it. (The same may be said of an engineer in charge of supervision of construction.) The client's own forces may be able to do this coordination; if they are not, a general consultant should be employed to do it.

Mr. Terzaghi is unquestionably correct in stating that the cooperation of consultants in high standing creates an unwarranted feeling of security, unless full advantage is taken of the services they are able to render. While a satisfactory formula for accomplishing this purpose has not yet been evolved, it must lie in the directions of coordinating their activities, and giving them all a chance to "follow through."