Quality Control "A Necessity Not an Option"

By Tom S. Ramsey, M. ASCE

Introduction

The construction phase of any civil engineering project is the most demanding and difficult portion of the project for the engineer. During this phase, the engineer's plans and specifications are put to the final test in terms of constructability, design performance and cost effectiveness. Too many projects are constructed that do not meet any of these basic requirements, causing complications for the owner, engineer and contractor, and sometimes resulting in a failure to meet safety obligations to the general public. How can this obligation be more effectively met and at the same time reduce construction complications? One very positive approach would be to implement a detailed quality control program early in the project.

Design Team Responsibility

It is the design team's responsibility to define and implement an adequate quality control program, and it is the owner's responsibility to recognize and support such a program. Too often quality control is addressed by ignoring problems and relying solely upon the contractor to meet the requirements of the project documents. Others may provide periodic or sporadic field inspections to ensure quality, but the contractor could still depart significantly from the requirements of the contract documents without the knowledge of the design professional. Clearly, it is difficult for even an experienced field inspector or engineer to ascertain, in just one day, the quality of construction efforts that have been going on for a matter of weeks. When the design team is not completely involved in the construction phase, the contractor must always ask himself whether a problem is significant enough to warrant contacting the design team. The contractor obviously can depart substantially from the contract documents without the knowledge or concurrence of the design engineer.

A great many project design firms are involved in construction on a limited basis, as previously described. In such cases, the engineer is only contacted when problems of a "job-stopping" nature arise. This is the "crisis approach" to quality control. And when the engineer receives the dreaded phone call informing him that his project has encountered problems and is shut down, it is usually too late for quality control. There

[1]P.E. and Mgr., Southwestern Labs., Inc., P.O. Box 8768, Houston, Tex. 77249.

Note.—Discussion open until May 1, 1985. To extend the closing date one month, a written request must be filed with the ASCE Manager of Technical and Professional Publications. The manuscript for this paper was submitted for review and possible publication on January 11, 1984. This paper is part of the *Journal of Construction Engineering and Management*, Vol. 110, No. 4, December, 1984. ©ASCE, ISSN 0733-9364/84/0004-0513/$01.00. Paper No. 19313.

are many marvelous "after-the-fact tests" that can be performed beneficially to reach solutions, but nothing beats good factual construction data on which to base judgments. Unfortunately, the engineer often does not have this necessary information and must base his solutions on assumptions rather than facts.

The effective implementation of such a program requires that the design team have discussions with the client or owner early in the project, preferably during the budget preparation phase. If the costs of quality control are dealt with as contingencies instead of being clearly defined in scope and number, the owner or client has no indication of their importance. Once the owner is convinced that quality control is not absolutely necessary, it will be very difficult to justify at a later date (e.g., two weeks before construction). "No money in the budget" is an unacceptable reason for bypassing adequate quality control.

Early quality control discussions with the owner should center around the need to obtain basic construction data for the engineer, to monitor the quality of materials and workmanship critical to structural integrity, to ensure that the owner gets what he has paid for, and to protect the general public's interest. If the owner understands these needs, then a reasonable cost-effective program can be developed prior to completion of the final plans and specifications. A knowledge of the quality control program during the planning phase will allow the engineer to incorporate it in his documents, thus clearly defining for the contractor what is expected prior to bid opening.

If the owner adamantly refuses to have the level of quality control set by the engineer, then further information may be needed. There are currently many articles and documented data being collected by the Architectural and Engineering Performance Information Center at the University of Maryland (3). This information could help the engineer explain to the owner the problems encountered—and their results—when inadequate control is allowed. Clearly, the engineer must be reasonably persistent and treat quality control as he would treat a sound safety factor—which is exactly what an effective quality control program can provide.

If a building is constructed in general compliance with the project documents, then its structural integrity is well-defined in terms of safety factors. However, if a building is completed without quality control and with little knowledge of or factual data on how it was constructed, then the integrity of the building cannot be defined. The engineer and owner are left with assumptions and possible risks.

The Association of Soil and Fundations Engineers (ASFE) has addressed this topic in a publication appropriately entited "Risks" (2). They note that "those who initiate a construction project—the owners—have the most to gain and so must accept most of the risk. How they deal with this risk often determines how much they gain, or lose." ASFE further states that most people attempt to avoid risk in order to achieve security. We as engineers cannot take this approach. Owners must be made fully aware of the risks involved and know which risks are acceptable and which are not in terms of cost and safety. A spirit of trust should exist between the engineer and owner as the options are received and decisions made. Only after a review of the risks involved in the

project can a proper budget be established and a sound program developed.

A major topic of discussion among most engineers today is liability. It is on our minds when the job is secured, when plans are develped, and throughout construction. We as engineers may have overreacted to liability and, consequently, avoided some of our project responsibilities in efforts to reduce "risk of the courtroom." We need to get involved in an effort to limit liability and be properly prepared for the shotgun blast of litigation in this "sue 'em all" age we live in. The development and implementation of a sound quality control program is certainly a primary means of becoming more involved in our project duing construction. In fact, one definition of adequate liability coverage may simply be a good quality control program. An editorial comment in the September 29, 1983, issue of the *Engineering News Record* (1) discussing the problems associated with the Miami Aerial Rail System, noted the following: "Too often the root of problems in construction is poor quality control discovered when a project is already well underway or completed."

When the design team is faced, ultimately, with having to provide less than adequate quality control, then adjustments in the project documents will have to be made in the interest of public safety. The contractor may then be required to provide more documentation of his work—documentation carried out, preferably, by an independent third party. The design may need to be "beefed up" to compensate for inadequate construction procedures and materials. Obviously, these types of measures can be costly and may still leave room for doubt and potential for problems. More importantly, these measures do not adequately address an engineer's obligation to the public or the profession.

Quality Control Program

As mentioned previously, the main ingredient of a soundly engineered approach to quality control during the construction process is the assurance that the engineer's "standard of care" remains as it is in the design phase. Other important ingredients are trained responsible inspectors, a materials engineering laboratory, well-defined controls, and communication. The ability of the project inspector will determine whether or not the program is effective. In many cases, the person selected as project inspector is a newly graduated civil engineer with limited construction background. This has been a positive way of training these graduate engineers and providing them with field experience that they will utilize throughout their engineering careers. However, without very close supervision, quality control will suffer and these young engineers will not be properly trained or motivated.

It is important that the inspector or resident engineer understand his responsibilities to the design team and owner. These responsibilities involve questions of professional ethics, as they relate to an engineer's charge to protect public health, safety and welfare. The resident inspector is simply an extension of the design engineer; he represents the design team in the field during construction. In the role of inspector, more pressures are placed and ethics tested than in any other capacity of the engineer. Because of this, the design engineer must work closely

with the field representative, especially when the inspector is a newly graduated engineer just beginning a career.

The inspector's primary responsibility to the design team (his employer) is to identify discrepancies which may be construction- or design-oriented. Once identified, these discrepancies should be reviewed and corrected if necessary. Certainly the engineer has design interests which should be the concern of the resident inspector. However, these interests will not normally contradict responsibilities to the owner and public. The end toward which everyone should aim is the project's structural integrity for its intended lifetime.

A major problem for the resident inspector is the difficulty of completing specified tests during construction. In most cases, the project documents clearly define what tests are to be performed, but the inspector has neither the equipment or knowledge to perform such tests. One solution to this problem is the early arrangement for a qualified engineering laboratory to assist the inspector. This type of relationship will facilitate the inspector's responsibility to document certain construction procedures. It will also help eliminate bad assumptions or opinions.

The materials engineering laboratory is an integral part of the quality control program, since it becomes the basis of the inspector's ability to monitor construction performance and the quality of materials incorporated into the project. By utilizing a technically qualified laboratory's equipment, and the experience of trained technicians and materials engineers, the inspector may more directly and quantitatively define the quality of construction. The results of tests performed according to rigid standard requirements are invaluable tools for resolving construction problems and removing doubt. Far too rarely does the design team use the extensive codes and test procedures available, even though a qualified materials laboratory may be readily accessible. Full use of available materials laboratory technology and personnel is within the scope of an engineer's obligation to his client and the public.

Another factor that will contribute to the success of a field inspector is the ability to communicate. The resident engineer, in addition to being the "spearhead" of quality control, is the liaison between design team and contractor. This requires that problems be brought promptly to the contractor's attention and that timely follow-up inspections be made. If resolution of the problem cannot be achieved in the field, then the resident engineer must involve the design team. Many problems, time delays and difficulties can be avoided if effective lines of communication are open between the contractor, inspector, engineer and owner.

Conclusion

If the project engineer develops a well-defined quality control plan, the construction phase can become less demanding and difficult. With such a plan, the construction phase will be smoother, the design performance as anticipated, and the whole project more cost-effective. This must be the design team's obligation—to formulate the best approach to quality control and relate it to the owner. The owner's responsibility is to reasonably support areas of quality control that may bear on the structural integrity of a facility or on the interests of public safety.

The design team must place as much emphasis and importance on quality control as they do on quality design. Quality control is not an option, but a necessity.

Appendix.—References

1. "Miami Aerial Rail System," *Engineering News Record*, Sept. 29, 1983, p. 188.
2. "Risk," Association of Soil and Foundation Engineers Loss Prevention Seminar, Silver Spring, Md., Feb., 1983, p. 3.
3. Vannoy, D. W., "'20/20' Hindsight Overview of Failures," Presented at the Oct., 1983, ASCE and ABA Conference on Construction Failures, held at Houston, Tex.