

PART I

Construction Quality

ASCE Manual 73: Background and Summary

JEROME S. B. IFFLAND

Subsequent to the Structures Failure Conference in 1983 in Santa Barbara, California, and a 1984 ASCE workshop in Chicago, ASCE accepted the role of producing a guide to quality in the constructed project. A steering committee was selected to plan and oversee the work. The steering committee developed an outline, statement of purpose, and principal themes for the guide and then enlisted some 40 authors and 90 reviewers to do the writing. ASCE also appointed a managing editor and a technical editor for the manual project. After several preliminary drafts, a preliminary edition text was developed. Some 12,000 copies of this text, which was designated for trial use over an 18-month period, were distributed. Comments were voluminous. On the basis of the comments, a completely rewritten text was prepared and published. This text reduced both the number of pages and the number of chapters and was rewritten by the editors rather than the chapter authors to provide consistency in style and format. The final text addresses the complete facility construction process from procurement of designers through construction, operation, and maintenance. Methods of improving quality include involvement of the design professional in construction, project peer review, quality assurance and control programs, clear definition of responsibilities, and appropriate compensation.

On December 15, 1967, the Silver Bridge over the Ohio River at Point Pleasant, West Virginia, collapsed with the loss of 46 lives. Approximately 10 years later, on January 18, 1978, the Hartford Civic Central Coliseum roof collapsed while the building was empty, so no lives were lost. Three months later, the Willow Island, West Virginia, reinforced concrete cooling tower collapsed during construction, which resulted in the death of 51 persons. On March 27, 1981, there was a failure of the Harbour Cay Condominium in Cocoa Beach, Florida, resulting in 11 fatalities and 23 injuries. The most spectacular failure in recent times was the collapse of the suspended walkways of the Hyatt Regency Hotel in Kansas City, Missouri, on July 17, 1981. This failure resulted in the death of 114 persons and the injury of almost 200. On April 15, 1982, Ramp C of the Riley Road Interchange in East Chicago, Indiana, failed during construction, resulting in 13 deaths. Finally, just before the decision of the ASCE to develop a quality manual, a span of the Mianus River Bridge, located in Greenwich, Connecticut, collapsed on June 28, 1983, with three killed and three injured.

These failures illustrate design mistakes, construction errors, and lack of adequate inspection and maintenance programs. Whereas a structural failure is an extremely rare event, when they happen the resulting publicity gives our design and construction industry a black eye. In the public's mind, some-

thing is wrong. Henry Petroski, in his entertaining and discerning book *To Engineer Is Human (1)*, has satisfactorily addressed this problem using many of these same examples and has pointed the way to the solution. As stated in the book, technology is not running amok; engineered structures have been failing for centuries. The first recorded failures were the result of the trial-and-error construction approach. After design concepts were developed and it was no longer necessary to rely on trial and error, there were still failures. They resulted from incorrect use of, or just plain wrong, design concepts. As these types of errors were reduced with advances in science and engineering, a new type of failure emerged—material failures. Properties of materials were misunderstood or misused. Fatigue and brittle fracture of steel and excessive autoclave expansion and alkali-silica reactions in concrete are examples of material failures that have been highlighted in recent years.

From the failures of the past, engineers have learned and have corrected and adjusted their approaches to design, construction, and maintenance of engineered structures. It can be said, at least for most of today's civil engineering structures, that we understand how to design them, the materials being used, how to construct them, and how to inspect and maintain them. Then, why have these recent failures occurred? The answer is simple: the quality of designs, construction, and inspection and maintenance programs is not keeping pace with the needs of our aging and deteriorating structures and with the exorbitant cost of failure. One of the main reasons for the situation has been an erosion of the acceptance of responsibilities over the years on the part of all concerned.

Engineers learn from experience and take steps to correct their ways of doing things. Facilitation of this process is the reason for ASCE Manual 73, *Quality in the Constructed Project (2)*. Engineers realize that something has to be done. The ASCE guide to quality is certainly a step in the right direction. Its use can define design and construction quality in our constructed projects along with an acceptable level of performance.

HOW THE QUALITY MANUAL GOT STARTED

The number of projects suffering significant accidents and failures annually constitutes only a very small percentage of those projects completed each year, and there has not been any significant change in the number and size of failures over the years. Nevertheless, the litigious nature of society and the associated high costs of losses, along with greatly expanded media coverage, have focused these problems in the eyes of

Iffland Kavanagh Waterbury, P. C., 1501 Broadway, New York, N. Y. 10036.

the public. Partly because of this focus, many members of the civil engineering profession believed that something should be done. Discussions were held on the subject at the Structures Failures Conference in 1983 in Santa Barbara, California, organized by ASCE. These discussions led to a 1984 ASCE workshop in Chicago attended by nearly 100 delegates from the design professions and the construction industry. The idea of a comprehensive guide to quality in design and construction grew out of this workshop. The ASCE accepted the responsibility of producing such a guide.

The ASCE board of directors established a five-member steering committee to manage preparation of the quality guide document and assigned the ASCE managing director of professional affairs to work with this committee. The first step was to develop an outline. In order to facilitate this, available quality assurance and control manuals and other pertinent related material were systematically collected. The result was several filing boxes of references. A consulting librarian was appointed to spend a summer reviewing these documents and prepare a list of key words culled from the tables of contents, the indices, and the texts. This list of key words turned out to be a document more than 70 pages long. One member of the steering committee took this list and developed a first draft of an outline. From this, the steering committee developed a detailed outline covering 24 chapters (later reduced to the present 22). Whereas the original instructions from the ASCE board of direction suggested preparation of a standard, the steering committee decided that standard language would not be used and that the document being prepared would not be a standard. In addition to the outline, a statement of purpose and a list of principal themes for author direction and guidance were prepared.

STATEMENT OF PURPOSE

The following objectives were formulated by the steering committee:

1. Provide guidelines and recommendations for owners, design professionals, and constructors on how to provide quality in constructed projects;
2. Clarify and define the roles, responsibilities, and limits of authority for owners, design professionals, constructors, and other participants in constructed projects;
3. Set forth general and specific definitions of critical words and phrases; and
4. Stress the importance of concepts and practices that improve quality in constructed projects.

The manual is intended for all parties connected with or interested in the design and construction process. It is not in itself a technical document or a guide strictly for design professionals. Its language, style, and format are intended for non-industry readers as well as for professionals and practitioners. Interested readers will include owners, engineers, architects, constructors, developers, users, operation and maintenance personnel, testing personnel, suppliers, inspectors, and subcontractors. It is also intended for attorneys, government officials, university professors, students, judges, and legislators.

PRINCIPAL THEMES

The principal manual themes were as follows:

- Definition and assignment of responsibilities;
- Importance of teamwork;
- Understanding of requirements and expectations;
- Importance of contract provisions defining the exceptions and obligations of the project team members;
- Principles of good communication;
- Owner's selection processes for project team members;
- Need for adequate scope, time, and liability protection;
- Procedures for design and construction;
- Organizational, management, and administrative practices;
- Conflict avoidance and the value of mediation;
- Benefits of peer review;
- Participation of the design professional during construction and start-up;
- Construction contract submittals, including shop drawings; and
- Standard form of agreements and other documents.

WRITING PROCESS

Once the outline, statement of purpose, and principal themes were completed, the steering group selected approximately 40 authors representing all parties associated with constructed projects—owners, developers, design professionals, contractors, insurance underwriter representatives, and facility operators. In addition, approximately 90 reviewers were selected to review individual chapters. The authors and reviewers are an outstanding group representing the top personnel in their professions. At the same time, the manual key staff was enlarged to include a managing editor and a technical editor. After the workers had completed their assignments and individual chapters had gone through several internal reviews and rewrites involving the reviewers and the steering group, a more formal review process was initiated.

REVIEW PROCESS HISTORY

The steering committee completed the first draft of the manual in October 1986. The second draft was completed in April 1987. From April to June 1987, more than 1,000 copies of the second draft were distributed to members of the design and construction industry across the United States, along with the approximately 50 other umbrella organizations associated with constructed projects. The recipients were invited to review the document and submit comments on its contents. The reviewers of the second draft represented nearly every segment of the design and construction industry and included representatives of ASCE, related professional societies and trade organizations, private firms, local and national government, universities, trade publications, and law firms. The reviewers submitted more than 800 pages of comments, which were reviewed by the steering committee and incorporated into the second draft text as appropriate.

During the review process, the steering committee developed an executive summary and a much-needed glossary. After incorporation of these additions, and following major rewriting on the basis of the review comments, a preliminary edition for trial use and comment was prepared and distributed and sold to more than 12,000 individuals and organizations. The readers were advised that this document was a draft and were invited to submit comments. The review period for the preliminary edition extended over the 18 months from June 1988 to December 1989.

PRELIMINARY EDITION TEXT

The preliminary edition document covered 192 pages. The steering committee was not entirely satisfied with this edition; it had been difficult to incorporate the many constructive comments and criticisms received during the interval review process. Many comments were received after the deadline and could not be incorporated at all. There was dissatisfaction about the overlapping areas that resulted from using some 40 authors. However, it was decided to issue the preliminary edition on schedule. Since it was clearly a draft, changes could be made later.

The preliminary edition included 24 chapters and a glossary. After an introductory chapter, two chapters were devoted to the benefits of quality to the owner and to his expectations and objectives. An important chapter on the communication and coordination process followed. Nine succeeding chapters covered selection of the design professional and were specifically related to procedures of design practices. Following design, another nine chapters discuss the construction process from planning, selection of a contractor, and contract administration through project start-up. This section included an important chapter on shop drawings and responsibilities. The preliminary edition closed with chapters on operations and maintenance and risk avoidance.

INITIAL IMPACT

As previously noted, approximately 12,000 copies of the preliminary edition were distributed. The comments received were voluminous in proportion to this massive distribution. The major comments received included the following:

- The text was too long. However, in most cases where this comment was made, there were also suggestions about expanding specific areas.
- There was duplication of material as well as conflicts in text from chapter to chapter.
- The title received many comments. The term "Manual of Professional Practice" was objected to by many.
- The text was overly oriented toward large design firms and large projects at the expense of small firms and small projects.
- There was the potential for increasing the design professional's liability if the manual were published. There were objections to specific language and to manual support of practices that were not necessarily standards throughout all geographical regions of the country.

- Specific issues were not covered adequately, such as the role of regulatory agencies, the site safety issue in the construction process, and the negotiated construction contract as opposed to competitive bidding.

- The educational nature of the manual should be stressed.

The foregoing only summarizes some of the common themes running through the thousands of comments received. There was also general support for the project. In general, the comments were constructive. However, apprehension was repeatedly expressed regarding the potential liability problems that could occur if the manual were officially issued by ASCE.

REVISED TEXT

On the basis of the comments received on the preliminary edition, the steering group decided on the following changes:

- Reduce the text from 180 to approximately 120 pages by pruning, condensing, and avoiding repetition and conflict.
- Place appendices at end of text.
- Rewrite text using descriptive rather than prescriptive language.
- Emphasize the aspirational and education aspects of the manual as well as emphasizing that it does not represent existing standards of practice.
- Use the generic format throughout.
- Remove the bias toward the design professional.
- Emphasize teamwork among participants while recognizing divergent objectives.
- Emphasize that laws and contracts govern assignment of responsibility.
- Stress site safety.

In addition to these general revisions to the text, specific changes to individual chapters were made, including the following:

- Reduce the executive summary to three or four pages stressing the owner's phase, the design professional's phase, and the constructor's phase of the work.
- Condense the section on selection procedures, reword using more positive language, and condense discussion of the two-envelope system of selection.
- Use the American Institute of Architects' rewrite of Chapter 10, which changed language from prescriptive to descriptive for entire volume.
- Combine the chapters on the use of computers.
- Emphasize the role of construction managers in the chapters on construction.
- Include negotiated contracts as well as competitive bidding in the section on selection of a constructor.
- Cover all types of shop drawings. (This was not done.)
- Rewrite the section on risk avoidance to eliminate design professional bias, and delete the discussion on insurance and bonds.
- Provide a new chapter on quality assurance and quality control.
- Change the title to eliminate the term "Manual of Professional Practice."

With these changes, the preliminary edition was rewritten and a first edition published. The preface emphasized the aspirational and educational nature of the document. To eliminate the fragmented approach of the preliminary edition, which used some 40 authors, all revised text was prepared by the managing editor and the technical editor. Authors were then requested to review the revised chapters.

FIRST EDITION

The revised manual incorporating these changes was reduced from 24 to 22 chapters and from 192 to 145 pages of text. The same format of delineating the owner's, design professional's, and constructor's responsibilities was not changed although there was some reorganization of the material to provide a better flow.

The preface to the first edition, designated hereafter as the Guide (2), summarizes what the Guide is and what it is intended to do. The following is from the preface:

This Guide has been written for all participants in a construction project, and describes a desirable *process* for project delivery from conception through design, construction, and operations start-up. It is a compendium of what the design and construction process should be to enhance quality. It contains descriptions of techniques, systems, methods, and procedures as contributed by numerous authors experienced in the process. It is not all-inclusive, and other options of equal or superior merit not mentioned in the guide may exist or may be developed.

The Guide discusses numerous aspects of the process likely to be pertinent for major projects; for smaller projects, some of these aspects may need only limited attention or may not apply at all. Likewise, a description of multiple staff *functions* for a project is not to be taken as a need for multiple staff *positions*, because, for many smaller projects, the functions often can be accomplished by a single individual.

The Guide is intended to be educational in nature, with the belief that embracing the philosophies and processes it describes will contribute to the quality of a project. It is not, however, a complete codification of practice within the construction industry, nor does it represent a "baseline" or minimum standard for correct or appropriate project development. Rather, it is intended as an aspirational document. The authors and editors had the benefit of a variety of resources, including printed materials and the comments of several hundred reviewers. The attempt was made to select from these sources and present factors contributing to quality in design and construction, with the hope of stimulating readers to identify areas where the levels of their practice can be raised.

The Guide should be used with care, since there is no satisfactory substitute for the exercise of prudent judgment by the owner, designer, and constructor. Moreover, the specific contractual provisions involved in a project may vary the procedures suggested in this Guide and, in that case, the specific contractual provisions govern.

Finally, the Guide will be a living document, subject to ongoing review coordinated by an oversight committee, and to revision at regularly scheduled intervals.

AREAS FOR IMPROVED QUALITY

It is anticipated that the ASCE Guide will have a future impact on construction. Specific areas where changes are needed that are supported by the Guide's recommendations are outlined here.

Design Professional Involvement in Construction

Most municipal, state, and federal agencies deliberately do not assign construction inspection contracts to the firms that designed the projects. There are several reasons for this policy, but the result is that quality in the constructed project is definitely compromised. The Guide takes the position that the design professional of record should be involved in the construction process and, indeed, advocates full involvement. Most professionals support this position; the only negative facet is the owner's unwillingness to pay adequately for this involvement. During the Guide review process, many federal agencies, though not practicing such a policy, supported the concept of the design professional's involvement and have acknowledged its positive effect on quality.

Project Peer Review

The Guide supports the concept of project peer review. One of the problems with this procedure is the possible incurrence of liability by the peer review firm or organization. The Guide attempts to address this issue and to define liabilities appropriately. Project peer review is presently seldom practiced; however, the advantages thereof and its impact on quality are obvious. Another problem has been the owner's reluctance to pay for such a review. Again, the Guide emphasizes the cost-effectiveness of such procedures with the intent of educating owners to institute project peer reviews.

Firm Peer Review

Whereas firm peer review is a growing practice, the full endorsement of this procedure by the Guide is expected to accelerate the process. Obviously, a well-run firm that has established acceptable managerial and administrative practices fosters better designs and improved contract documents than other firms.

Quality Assurance and Quality Control

Quality assurance and quality control programs and procedures are encouraged by the Guide for both the design professional and the constructor. The need for the owner's recognition of the value of such programs is pointed out, and the cost-effectiveness of the owner's paying for such activities is emphasized. Such programs are certain to have a major impact on quality in the constructed project.

Shop Drawing Responsibility

Notwithstanding the legal liability assumed by a detailer preparing shop drawings when he designs connections, and regardless of any specification requirement that a licensed professional engineer be used, the Guide clearly states that the design professional of record has full responsibility for the extensions of his designs that are shown on the shop drawings.

This responsibility cannot be assigned or transferred or abrogated by exculpatory language in shop drawing approval stamps. The result of this clear definition of shop drawing responsibility is that design professionals will assign experienced personnel to check shop drawings rather than delegating such activities to junior and perhaps unqualified members of the staff. The result should be a positive impact on the quality of construction.

Equitable Compensation

As noted in several preceding items, the Guide emphasizes the cost-effectiveness of various practices and procedures and encourages owner recognition of the need to adequately compensate both the design professional and the constructor for following them. It is well recognized that small investments in these areas pay off handsomely in terms of quality, the meeting of objectives, and final total project costs.

Definition of Responsibilities

While responsibilities are assigned contractually as well as being legal obligations, the Guide suggests clearly defined areas of responsibility for the several parties involved in the constructed project. This approach has already motivated several organizations that prepare standard contracts to review their documents with the intent of revising them to reflect similar positions. It is hoped and anticipated that the Guide will provide the impetus for governmental agencies to do the same.

SOME OUTSTANDING ISSUES

Comments by National Society of Professional Engineers

After the Guide was published, the National Society of Professional Engineers (NSPE) reviewed the document again and made several suggestions for future editions.

Preface

NSPE recommends that the preface should imply that the Guide represents an absolute, that the Guide be referred to as a "publication" rather than a "guide," and that reference to the Guide as an "aspirational document" be deleted.

Chapter 21—Shop Drawings

The design engineer of record should specify the type of inspection required, and such inspection should be performed by inspectors approved by the design engineer. This statement was addressed mainly to construction components fabricated off the construction site.

Language should be added dealing with the problem of temporary construction loads, which could compromise the

structural integrity of the facility either during or after construction. The design engineer of record should either approve the temporary construction loads proposed by the constructor or include, in the specifications, stated load limits that apply during the various stages of construction.

Independent testing of construction materials and components should be performed in a laboratory approved by the engineer of record and employed by the owner, to ensure independence of test results.

Chapter 5—Procedures for Selecting the Design Professionals

Add the following to the Introduction to incorporate greater emphasis on total quality management techniques:

The capital, operation and maintenance costs, along with the reliability and life cycle of the constructed project, are determined in the design process. Seldom will the least-cost design result in the minimum capital or life-cycle cost for the owner. Modern competitive practices of total quality management have shown that a quality oriented teamwork approach between the owner and his engineering design firm will result in maximum owner satisfaction. Lowest design cost will not result in the best quality or minimum project costs.

Add the following to the Section 5.2, Basis for Selection:

Design services during construction should be clearly defined. A cost allowance must be made for the design professional to be able to assure that the constructed project is meeting the design specifications. Critical hold points during construction should be specified by the designer and design compliance should be verified by inspectors agreed to by the designer. Some construction means and methods including temporary material or equipment loads on the partially completed structure could compromise the structural integrity. The design engineer should participate in the review and approval of any construction means and methods which require engineering knowledge and analysis of the facilities structures load limits.

Comments by American Consulting Engineers Council

After the preliminary edition was published, the American Consulting Engineers Council (ACEC) board of directors voted to reject it. After the first edition was published, the ACEC board of directors voted not to reject the Guide, by a vote of 461 to 359. The closeness of this vote emphasizes how practicing engineers feel about the Guide. A large number of ACEC members are essentially "one-man" firms. These firms do not have the staff to check designs and represent themselves on the construction site, nor do they necessarily want to add staff so that these things can be done. Working for themselves, they have no problems with social security, unemployment taxes, employee benefits, and so forth. They may be simply taking a position against anything that threatens their status quo.

In addition, a large number of ACEC members stress the liability that may be associated with a published, authoritative ASCE Guide. They fear the Guide will be used against them in lawsuits. This argument may possibly be a cover-up for not wanting to perform quality work as defined by the ASCE

Guide, on the basis of the belief that clients will not pay for such performance.

BENEFITS

Whereas it is expected that adoption of the principles set forth in the Guide will foster quality in the constructed project, there are several important corollary benefits:

- The first is, obviously, fewer failures—both during construction and after the project is finished.
- There should be a reduction in change orders during construction. The owner is never happy about change orders, and the constructor is never happy with the compensation for them. The design professional, who is commonly caught in the middle, will also benefit.
- There will be less litigation. At present a large number of construction contracts end up with claims that must be settled in arbitration or in court. Reduction in claims is a major saving to all parties involved in the constructed project.

- Teamwork will be enhanced by designing and building projects without extensive problems, and a closer, more trusting relationship will develop between the interested parties leading to increased cooperation on constructed projects.

- Finally, increased quality in design and construction will result in better-satisfied owners, whose objectives and expectations have been met, and better-satisfied design professionals and constructors, who can take increased pride in their work.

REFERENCES

1. H. Petroski. *To Engineer Is Human*. St. Martins Press, New York, 1985.
2. *Quality in the Constructed Project*. Manuals and Reports on Engineering Practice 73. ASCE, New York, 1990.

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