PART 3

TECHNICAL SPECIFICATIONS

CHAPTER 14

PURPOSE AND USE

14.1 Role of Technical Specifications

Technical specifications are written instructions and requirements that accompany construction drawings. The term *specification* is used interchangeably with *technical specification.* Used together, the specifications and drawings comprise all of the technical construction requirements to complete a project. They are part of the contract documents. As such, they carry certain legal implications. As discussed later, specifications and drawings should not contain duplicate information; however, in the event of a conflict between drawings and specifications, the provisions of the specifications usually take precedence. Therefore, the preparation of specifications should receive as much attention as that of drawings.

In general, specifications contain all necessary information that is not shown on the drawings. Specifically, specifications for a civil design project contain the following information:

1. Detailed material requirements, including quality standards
2. Testing requirements for quality control and quality assurance
3. Procedures for installation or placement of materials and equipment, including tolerances
4. Schedules or lists of materials or equipment otherwise not shown on the drawings
5. Coordination of work among different trades and disciplines, including restrictions, conflicts, and limitations
6. Submittal and schedule requirements
7. Measurement and payment provisions for all work items
8. Miscellaneous general requirements (e.g., environmental abatement, safety) that cannot be depicted on the drawings
9. Permits obtained by the owner
10. Reference data such as climatic data, stream flow records, field and laboratory test data, and records of existing site and facilities
11. Coordination with other contractors on site
12. Safety issues and responsibilities

14.2 Users of Specifications

For the most part, specifications are written for the constructor (contractor) and his or her subcontractors, fabricators, and material and equipment suppliers. The other two parties of a construction contract (the owner and the engineer) also use the specifications. The following is a description of how these three parties use the specifications.

Contractor

A contractor uses specifications when he or she expresses an interest to bid on a project. Based on the scope of work required in the specifications, the general contractor assembles a team of subcontractors, material suppliers, and equipment manufacturers. The first user within the contractor's organization is the cost estimator, who is responsible for bid preparation. In preparing his or her bid, the cost estimator uses the material and equipment requirements to obtain quotes and determines what contingencies to put in the bid for uncertain and risky factors. He or she also determines what labor categories and construction equipment are suitable for the project and arrives at the labor and equipment costs.

It is, of course, during construction that the construction crew uses the specifications. In the contractor's office, the manager prepares the required submittals (e.g., materials test data or shop drawings), orders the materials and equipment, schedules the required crew and equipment, and handles progress payments. In the field, the superintendent directs his or her crews, and sometimes his or her quality control testing personnel (depends on contractual arrangements), and receives materials and equipment delivered to the site. He or she interacts with the resident engineer to confirm or inquire about specified requirements. Compliance with permit requirements in the specifications is also a task for the contractor.

Material suppliers and equipment manufacturers or distributors furnish products based on the specifications. Compliance with the specifications is usually handled through the submittal process and testing.

Owner

There are several reasons that an owner is interested in the contents of the specifications. The first reason is that an owner needs to know what he or she is buying for the money he or she is spending. Secondly, an owner may have certain preferences (e.g., for a brand name with good past performance or consistency with the spare parts inventory) regarding products or end results. Thirdly, for operation and maintenance of the new facility, an owner will need a record of what is being built.

Engineer

Typically, the owner hires the engineer who prepares the specifications to engineer and manage construction. This arrangement is frequently the case in private-sector construction. Some government agencies have their own construction management teams, and the design engineer is hired during construction to perform certain technical tasks only. Regardless of the arrangement, the resident engineer has the responsibility of overseeing enforcement of the specifications during construction. He or she interacts with the contractor superintendent and foremen, directs his or her field inspectors and quality assurance testing personnel, communicates with the designer, checks the materials and equipment delivered to the site, and verifies permit compliance. It is important to consider the resident engineer's authoritative limitations. He or she does not have the authority to direct the contractor. For unacceptable work, the resident engineer should inform the owner, who is then responsible for notifying the contractor to fix the problems and to comply with the specifications.

14.3 Relationship with General and Supplemental Conditions

The general conditions and supplemental conditions define the duties and responsibilities of the owner, the engineer, and the contractor regarding all contractual issues (administration, technical issues, bonds and insurance, payment, dispute resolution, deliverables, and submittals). Technical issues in general and supplemental conditions are handled differently from document to document and from owner to owner. The general conditions by Engineers Joint Contract Documents Committee (1990), for example, define the guidelines for items related to technical specifications as follows:

- Reference to standard specifications (such as American Society for Testing and Materials [ASTM], American National Standards Institute [ANSI]) and specifications of technical societies (such as American Concrete Institute [ACI], American Water Works Association [AWWA]). Version of these standards is defined, and guidelines are provided to resolve conflicts between these reference specifications and the contract specifications.
- Definitions of the contract parties referenced in the specifications. These parties include the owner, engineer, contractor, subcontractor, supplier, and manufacturer.
- Meanings of certain terms used in the specifications that are open to interpretation. These terms include *as directed, as allowed, to the satisfaction of, acceptable to,* etc.
- Definition of changed conditions.
- Contractor's responsibilities on safety and his or her labor, equipment, and materials.
- Handling of substitutes and items pertaining to *Or Equal* provisions.
- Conditions of the site and site cleanliness.
- Submittal procedure and handling of shop drawings.
- Owner/engineer's testing and inspection.
- Protocol on rejecting, correcting, and accepting defective work.
- Warranties.

Because the general and supplemental conditions contain so many references to specifications and drawings, it is important that the specification writer is thoroughly familiar with these contract documents so that the technical provisions are consistent with these documents. It is vital that a knowledgeable reviewer checks all cross-references between documents.

14.4 Relationship with Drawings

Specifications and drawings work hand-in-hand. The correlation between specifications and drawings has been compared to a dovetail joint in woodworking, a union of two parts that complement each other and fit together with no overlaps and no gaps (Construction

Specification Institute, 1996d). Some general correlations between specifications and drawings are listed below:

- Consistent terminology should be used in specifications and drawings. Inconsistent terminology between the documents results in confusion, errors in construction, disputes in acceptance of work and payment, changed conditions, and claims. Some examples of inconsistent terms used in drawings and specifications are:

  Material Types and Classifications
  In earthwork, when a material called *random fill* is used in the drawings, the same term should be used in the specifications. This term should not be called *compacted fill, fill, backfill* or other names in the specifications. This distinction is particularly important in a large earthwork project, when several fill materials are required. Each fill material will have a designation, such as *general fill, random fill, embankment fill, structural fill, select fill,* etc. In concrete work, when a material called *backfill concrete* is used in the drawings, this term should not be called *mass concrete* or *lean concrete* in the specifications. In mechanical work, a *sluice gate* shown on the drawings should not be called a *slide gate* in the specifications, because these two types of gates have some significant differences in quality and performance.

  Facility and Project Feature Components
  When a *ditch* is shown on the drawings, the specifications should not refer to this feature as a *trench.* When a *cofferdam* is called out on the drawings, this feature should not be referred to as *protection barrier* or *enclosure* in the specifications. When a *spillway* is shown on the drawings, that feature should not be called *sluiceway* or *outlet* in the specifications. When a *chamber* is used on the drawings, that feature should not be referred to as a *vault* or *adit* in the specifications.

- There should be no duplication of information on the drawings and specifications. Strictly speaking, there is no harm in duplicating exact, consistent information on both documents. However, this practice may result in problems when that information is changed during design, bidding, and/or construction. Unless identical changes are made in both documents, conflicts and discrepancies will be the result.

- Specifications are used to give a detailed description of materials and equipment, and that function should not be repeated on the drawings. It is a good practice to call out materials or equipment on the drawings by names or designations, but reserve the specifications for its full details. This practice avoids excessively long callouts or notes on the drawings (see Section 8.3) while allowing the written format of the construction documents (the specifications) to describe the required quality and performance. Some examples are given below.

  Subgrade Preparation
  When subgrade preparation is needed below a structure, the drawing should only show the limits, while other preparation requirements can be handled by calling out "subgrade preparation, see specifications." In the specifications, subgrade preparation requirements of depth of scarification, moisture conditioning, proof-testing, and compaction can be described in details.

  Construction Joint
  When a construction joint is needed in a cast-in-place concrete structure, the drawing should only show "C.J.," which is a commonly used abbreviation for construc-

tion joint. In the general notes of the drawings, a reference to the specifications can be used for all construction joints. In the specifications, construction joint requirements of cleaning, sand-blasting, high-pressure water jetting, and criteria of acceptance can be described in detail.

- Specifications can be used as an extension of the drawing features that require excessive amounts of text descriptions. Drawing features with excessive amounts of text include schedules of materials or equipment and notes. From a production standpoint, it is much faster to produce or change these schedules and long notes with word processing software than with CAD software.

The timing of specifications preparation during design is important in obtaining a quality design product. In the production of construction documents, it is common for designers to start with drawings, which require a significant amount of the design effort. On the contrary, specifications preparation is usually relegated near the end of the design process, as if the document is an afterthought. Some of the reasons that designers give for this practice are:

- Specifications cannot be completed until most of the drawing features are identified and drawn.
- Writing specifications is not pleasant, and given a choice, a designer would rather engage in a more pleasant activity, such as drawing preparation.

Specifications that are prepared in a hasty manner contain errors, omissions, discrepancies, and inaccuracies that impact bid prices, result in serious construction problems, and cause claims. Numerous court cases demonstrate that when a conflict arises between drawings and specifications, the court usually rules favorably toward the specifications (Fisk, 1992). According to Federal Acquisition Regulations (FAR) for contract construction, the preference for specifications over drawings is standard. So, regardless of how perfect the drawings are, a defective set of specifications accompanying these drawings will cause serious problems on a project.

Under an ideal situation, specifications should be prepared concurrent with drawing production. However, there are limitations within the design industry—man-power availability, schedule constraints, and budget constraints—that make it difficult to achieve this goal. Rather, the following compromise approach is suggested:

1. Using project and design requirements as a basis, establish a draft Bid Schedule at the start of a project.
2. Prepare a preliminary list of drawings.
3. Prepare a list of technical specification sections.
4. Start detailed specification preparation when the drawing production is 60% to 70% complete. At this stage, all of the design features, materials, equipment, and other project requirements are identified, thus allowing detailed specifications to be developed.

When referencing drawings in the specifications, the specification writer should resist referring to detailed locations of the drawings (e.g., "as shown on Section A of Sheet 7," or "as shown on Detail 6 of Sheet 10"). Drawing sheet numbers and section and detail designations and locations frequently are changed and moved during the course of drawing production. Therefore, a constant updating effort will be required in the specifications. The suggested practice in referring to drawings is to state simply "as shown on the drawings." It is the responsibility of the contractor to locate the feature on the drawings.

CHAPTER 15

TECHNICAL AND DESIGN ISSUES

15.1 The Specification Writer

This section addresses the question: Who should write the specifications? For this discussion, the person who prepares the specifications is called *specifier*. Traditionally, technical specifications are prepared by the following personnel categories:

1. Design engineers who are also involved with engineering analysis of the project and production of the construction drawings. Depending on the different disciplines for a particular project, more than one engineer may be involved.
2. In-house specification writers whose sole responsibility is to prepare specifications. These are professionals who have certain basic training and experience in writing specifications, but who are usually not involved directly in the analysis and production of construction drawings. They may or may not be engineers. This approach is usually used in large engineering firms or large government agencies such as the U.S. Army Corps of Engineers or the U.S. Bureau of Reclamation.
3. Specification writers contracted from outside the engineering firm. The qualifications and experience of these outside specifiers can be assumed to be equal to, or better than, those of the in-house specifiers.
4. Staff engineers who have no previous involvement with the project or have little experience in specifications writing, but are assigned this task because they are available and are lower-paid staff.

The best specifier for civil engineering design projects should fit into Category 1 (above). Design engineers understand the technical requirements and design intent for projects, are familiar with site conditions and site constraints, and coordinate well with construction drawings because they are involved directly with production. It is important that specifiers work within their areas of expertise. In fact, all state Boards of Registration for Professional Engineers (see discussion in Chapter 12) require this. For example, specifications on excavation, dewatering, and earthwork should be prepared or supervised by geotechnical engineers; and specifications on structural concrete and fabricated steel should be prepared by structural engineers. Another important qualification for an engineering specifier is field experience. A specifier with little or no field experience, no matter how technically qualified, is likely to produce specifications that may not be constructible or may be so difficult to construct that the cost will increase. Lack of field experience in construction specifiers is one of the most common complaints from contractors.

In large organizations, especially for large projects, technical specifications are prepared by in-house professional specifiers that fit into Category 2. This arrangement has been used successfully for many years. Some of these specifiers do not have engineering training, but most of them have vast construction experience, either as contractors or construction managers. Some of them are certified by professional organizations, such as Construction Specifications Institute. Assuming these in-house specifiers are qualified to prepare specifications, the success of producing a set of well-prepared project specifications should include the following work on the part of the specifiers:

- A visit to the project site to become familiar with site conditions and site constraints
- Meetings with lead design engineers to gain an understanding of design criteria, design intents, and testing requirements
- A review of partially completed or nearly completed construction drawings
- A review and understanding of the basis of the bid schedule
- Obtaining from the design engineers a list of materials, product data, or material sources
- Agreeing on terms and names to be used in the drawings and specifications

The main advantage of using in-house professional specifiers is that the design engineers can continue to focus on designs, design drawing production, and design report preparation. This in-house resource, when properly used, is a valuable asset in a design-oriented organization.

The considerations for outside professional specifiers that fit into Category 3 are similar to those of in-house specifiers, except in that they are brought in near completion of the project. When the schedule of producing the specifications becomes critical, there is a tendency on the part of the designers to limit some of the information available to the specifiers. Therefore, it is up to the specifiers to request additional information during the production process. When adequate time is available and the budget allows for it, engaging outside professional specifiers should achieve similar success as that of in-house specifiers.

Using specifiers that fit into Category 4 should be avoided. In the long run, the cost of producing a set of well-prepared specifications will likely increase because of significant changes required during the review process. In the worst scenario, errors in the specifications will not be detected until construction, resulting in cost overruns, claims, and disputes.

The American Society of Civil Engineers Committee on Specifications of the Construction Division conducted a questionnaire survey of more than 600 private owners, design professionals, and municipal, state, and federal agencies regarding various topics related to specifications (ASCE, 1979). One of the questions—what minimum qualifications should a specifications engineer possess?—is relevant in this discussion. The following is a list of qualifications provided by the respondents, in order of decreasing importance:

1. Field (construction experience), frequently expressed in the 5-year to 10-year range, with a few suggesting resident engineer experience
2. Engineering degree

3. Professional registration
4. Design experience
5. Design and field (construction) experience
6. Technical writing ability
7. Prior knowledge or understanding of project
8 Legal understanding, knowledge, or education
9. Knowledge of materials and their availability
10. Fluency in English and ability to communicate
11. Specification writing experience
12. Two years of college education
13. Common sense
14. Knowledge of Construction Specifications Institute
15. Formal training in specification preparation
16. Project manager
17. Master's degree
18. Familiarity with state standards or local codes
19. Maintenance experience
20. Research ability
21. High school graduate
22. Principal of firm

It is interesting that the "Principal of firm" is listed dead last, behind "High school graduate." From the perception of owners, the principal of a firm is least qualified to write technical specifications. Some of this perception is unfounded, as some principals are well qualified with sound field and design experience and technical backgrounds.

15.2 Problem Areas

Many claims and construction disputes arise from problem areas associated with technical specifications. This section first identifies what most of the problem areas are, and the remainder of this section and Chapter 16 discuss how to mitigate these problems. The following is a list of problem areas in specifications, in no specific order, that could lead to disputes, claims, and/or litigation:

Technical Inaccuracy

This problem area pertains to inaccurate technical data in the specifications and deficiencies in product performance requirements. The sources of this problem may not be self-evident without some investigation on the nature of the inaccuracy. When a design engineer