NISTIR 89-4094

Guide Specifications and Reference Specification System

Robert G. Mathey and James R. Clifton

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
National Engineering Laboratory
Center for Building Technology
Gaithersburg, MD 20899

June 1989

Prepared for:
Naval Facilities Engineering Command
Design Support Office
Alexandria, VA 22332-2300

NISTIR 89-4094

Guide Specifications and Reference Specification System

Robert G. Mathey and James R. Clifton

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
National Engineering Laboratory
Center for Building Technology
Gaithersburg, MD 20899

June 1989

National Bureau of Standards became the National Institute of Standards and Technology on August 23, 1988, when the Omnibus Trade and Competitiveness Act was signed. NIST retains all NBS functions. Its new programs will encourage improved use of technology by U.S. industry.

Prepared for:
Naval Facilities Engineering Command
Design Support Office
Alexandria, VA 22332-2300

U.S. DEPARTMENT OF COMMERCE
Robert Mosbacher, Secretary
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Raymond G. Kammer, Acting Director

ABSTRACT

Guide specifications enable faster, more efficient, and cost-effective preparation of construction project specifications. By editing guide specifications instead of writing new requirements for each project, the produced construction project specifications are also generally of higher and more consistent quality, and should lead to less disputes and litigation. Established national specifications are referenced in guide specifications and this technique has proven extremely effective in communicating material, product, system, and construction requirements. Reference specifications are also used for workmanship standards.

This report is based on a study aimed at evaluating the need for and the effectiveness of Navy guide specifications and the selection and need for reference specifications in guide specifications. Decision rules were developed to assist in the selection of the most appropriate reference specifications. Tiering of referenced documents in guide specifications was assessed with regard to the volume of reference material that the contractor and contract administrator must study and act upon to comply with the terms of the contract. Recommendations on ways to improve Navy guide specifications and to resolve issues dealing with selection of reference documents and with their tiering are presented.

Keywords: construction; construction project specifications; federal construction; guide specifications; NAVFAC; reference specifications; specifications; specification tiering; standards; tiering.

TABLE OF CONTENTS

Page

ABSTRACT iii

LIST OF FIGURES vi

LIST OF TABLES vi

EXECUTIVE SUMMARY vii

1. INTRODUCTION 1

2. OVERVIEW OF SPECIFICATIONS FOR CONSTRUCTION 3

2.1 Purposes of Specifications 3
2.2 Construction Project Specifications 3
2.3 Master Specifications 6
2.4 Some Considerations in Preparing Specifications ... 7

3. GUIDE SPECIFICATIONS 9

3.1 General Aspects 9
3.2 Development and Revision 11

3.2.1 Federal and Commercial Guide Specification Developers 12
3.2.2 Contents and Format 15
3.2.3 Updating of Specifications 17
3.2.4 Proprietary Products and Systems in Specifications 18
3.2.5 Concluding Remarks 19

3.3 Current Use of Guide Specifications 20
3.4 Advantages of Using Guide Specifications 21
3.5 Assessment of DoD Guide Specifications 24

4. COMPARISON OF NAVFAC AND OTHER FEDERAL GUIDE SPECIFICATIONS 27

4.1 Information from NASA Report 29
4.2 Computerized Construction Criteria 31

5. REFERENCE SPECIFICATIONS AND STANDARDS IN GUIDE SPECIFICATIONS 32

5.1 Need and Use 33

6. DECISION RULES FOR SELECTION OF REFERENCE SPECIFICATIONS AND STANDARDS 38

TABLE OF CONTENTS (Continued)

Page

6.1 Decision Rules 38
6.2 Application of Decision Rules 41

6.2.1 Procedure for Applying Rules 41
6.2.2 Comments on Reference Specifications in Guide Specification NFGS-03300 42

6.3 Findings from Decision Rule Application 43

7. TIERING OF SPECIFICATIONS 48

7.1 Examples of Tiering in Specifications 49
7.2 Types of Reference Specifications in Tiers 51

8. CONCLUSIONS AND RECOMMENDATIONS 52

9. ACKNOWLEDGEMENTS 56

10. REFERENCES 56

LIST OF FIGURES

Page

Figure 1. Tiers of Reference Specifications in Guide Specification NFGS-03300, Cast-In-Place-Concrete .. 60

Figure 2A. Tiers of Reference Specifications in Guide Specification NFGS-03302, Cast-In-Place-Concrete (Minor Construction) 61

Figure 2B. Tiers of Reference Specifications in Guide Specification NFGS-03302, Cast-In-Place-Concrete (Minor Construction) 62

Figure 3. Tiers of Reference Specifications in Guide Specification NFGS-03501, Insulating Concrete Roof Deck System 63

LIST OF TABLES

Page

Table 1. Types and styles of Construction Project Specifications as Described by Lewis [4] 64

Table 2. Examples of Types of Reference Specifications in Tiers 65

EXECUTIVE SUMMARY

I. BACKGROUND, PURPOSE, AND SCOPE

The successful transfer of project requirements from the designer to the contractor is dependent on the adequacy of the specifications. Guide specifications are used to facilitate the preparation of construction project specifications in Federal construction projects. Reference specifications are used to reduce the size and complexity of guide specifications. Guide specifications containing many requirements may require many reference documents or reference specifications. The reference documents will likely contain references resulting in tiering of references and the creation of a specification hierarchy or specification tree. Since the number of reference documents greatly expands with tiering, the tier level for which the contractors have the responsibility for fulfilling the requirements of reference specifications needs to be resolved.

The Naval Facilities Engineering Command (NAVFAC) is evaluating the need and effectiveness of Navy guide specifications. NAVFAC asked the National Institute of Standards and Technology (NIST) to review the uses and advantages of guide specifications in preparing construction project specifications and to develop a methodology for selecting and determining the appropriateness of each reference document given in a guide specification. The results of the NIST review and study are presented in this report. The major subjects addressed were:

- the NAVFAC guide specification system
- the uses and needs for construction project specifications
- the uses and advantages of guide specifications
- the uses, advantages, and importance of quality reference specifications
- development of decision rules to determine the need for reference specifications and for their selection
- tiering of reference specifications and the responsibility of contractors for fulfilling the requirements of reference specifications

In carrying out this review, three NAVFAC guide specifications dealing with concrete construction were analyzed to:

1. evaluate the completeness of the decision rules developed to determine the appropriateness of the reference specifications, and

2. illustrate the extent of tiering of reference specifications and to determine the types of specifications in the different tiers.

II. CONSTRUCTION PROJECT SPECIFICATIONS

A construction project specification is a legal document setting forth all the requirements for one project. The construction project specification does not usually include drawings or symbols, but describes all of the work statements that augment a drawing which gives the requirements for quality, testing, installation methods, and other factors. Federal construction mandates maximum full and free competition and the awarding of contracts to the lowest bidder. These factors along with the policy of Federal agencies to use generic specifications creates a difficult atmosphere for preparation of quality construction project specifications. Thus, Federal construction project specifications require more detailed and precise wording than specifications for commercial construction projects.

Federal construction project specifications are based on guide specifications. Without available applicable guide specifications, it would be necessary to provide a complete description of the material and the installation in such terms that only one, or a very small number, of products can be supplied in accordance with the specifications. This procedure would result in contract specifications that would be contrary to Federal policy. Clearly, the most desirable approach for preparing construction specifications is to use guide specifications. This approach will facilitate the incorporation of state-of-the-art materials and construction methods which will enhance the quality of construction.

III. GUIDE SPECIFICATIONS

Guide specifications are critical for the effective preparation of construction project specifications in Federal and most commercial construction projects. Adequate guide specifications can enhance the quality of the work and the construction materials in every stage of the overall construction process, such as for:

- design
- procurement of appropriate materials and products
- construction procedures
- inspection
- testing

Guide specifications are the primary source documents which are edited and tailored by designers in preparing the technical requirements for construction projects. They ordinarily cover a variety of situations, and they cannot be used for a specific procurement without editing. It is the policy of all Federal agencies to use nonproprietary or generic specifications and not brand names to describe a product and its characteristics in guide specifications.

Guide specifications provide a centralized source for most of the information needed in the development of particular project specifications. This saves preparation time, reduces preparation costs, and improves the comprehensiveness and quality of the requirements. Automated techniques can further improve the process. The major advantages of using guide specifications to produce construction project specifications instead of writing a new set of requirements for each project are:

- faster, more efficient, and cost-effective preparation of construction project specifications
- higher and more consistent quality of construction project specifications
- easier to use construction project specifications that should lead to less disputes and litigation.

IV. REFERENCE SPECIFICATIONS

It is common practice in construction project specifications to require various materials, products, and components to conform to standards and criteria stated in other publications. When referenced, these publications became a part of the construction contract. All major guide specification systems use established national reference specifications and standards to effectively communicate material and construction requirements. Reference specifications are also used for workmanship standards. Reference specifications constitute one of the major communication and control mechanisms for the building industry and influence appreciably the design and quality of the constructed or manufactured product. A major purpose of the reference specifications is to control the quality of the material or product and to minimize the size and complexity of the project specifications and procurement documents. The major advantages of using reference specifications are because they:

- are an effective communications tool
- are universally accepted
- are cost-effective

- offer options for various levels of performance
- provide for standardization of manufactured products and fabrication procedures
- provide established test methods to measure the quality of products and materials
- provide specifications for quality of materials, products, and workmanship.

Decision rules were developed in this study to determine the need for reference specifications. The decision rules were also intended for use in deciding if particular reference specifications could be deleted, others added, or if only limited portions should be referenced instead of the entire document. The decision rules were applied to three example construction guide specifications. The decision rules were intended for use in selecting the most appropriate reference documents which adequately address the needed criteria, requirements, and provisions. They also can be used to avoid conflicting, confusing, ambiguous, unobtainable, and unenforceable requirements in guide specifications. The major decision rules for determining the need for reference specifications developed in this study are:

- are they applicable?
- do they provide for state-of-the-art practices?
- are there inconsistencies in the provided information?
- are the requirements enforceable?
- do they void or conflict with provisions in the guide specification?
- are they the latest revision?
- does the entire document need to be referenced or only specific portions?
- are the requirements clear and unambiguous?
- do they cover needed requirements?

V. TIERING OF SPECIFICATIONS

The number of reference specifications in a guide specification may vary depending on the scope and extent of the work specified. Each reference specification generally lists applicable documents which form a part of the reference specifications to the extent referenced. This process is repeated on several levels in that

the reference specifications in the guide specifications also contain reference specifications. This leads to tiers of specifications which pertain to each level of referenced specifications.

Three guide specifications were analyzed in this study to illustrate the extent of tiering of reference specifications. It was found that the first tier was mostly material or product specifications. For the second through the fourth tiers, over 80 percent of the reference specifications in each tier were related to testing. It was also found that the total number of reference specifications through Tier 4 in the guide specifications could number in the thousands. Thus, there is a vast number of reference specifications for the prime contractor to review and determine his responsibility for their requirements. The results of the study along with practical considerations suggest that the prime contractor's responsibility for fulfilling the requirements of reference specifications should be limited to the first tier only. Proper certification and labeling of materials, products, and systems therefore should be required in the guide specifications to support the prime contractor in contracting with his subcontractors and suppliers in order to fulfill this responsibility.

IV. CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations from this study primarily address the NAVFAC guide specification system. The major conclusions and recommendations are:

- The NAVFAC guide specification system forms an effective basis for the preparation of Navy construction specifications.
- The reference specification system be continued in NAVFAC guide specifications.
- The latest revision of reference specifications be used and that the review of new reference specifications be conducted by a technical expert rather than a specifications writer.
- The developed decision rules for reference specification acceptance should be further evaluated for forming a basis for determining the appropriateness of reference specifications.
- The prime contractor be responsible for only the requirements in the first tier of reference specifications. Proper certification and labeling of materials and products must be required in the guide specifications to support the prime contractor in order to fulfill this responsibility.

- The feasibility of using a computerized system for preparing contract specifications from guide specifications be studied.

1. INTRODUCTION

Specifications are a means for conveying the purpose, requirements, and details of a construction project from the owner or the owner's agents to a contractor. The successful transfer of the project requirements from the architect/designer to the contractor is dependent on the adequacy of the specifications. Guide specifications are used to facilitate the preparation of construction project specifications in Federal and most commercial construction projects. In preparing construction project specifications, appropriate sections of guide specifications are selected, and if necessary, supplemented by additional documentation covering any unusual aspects of the project. Each guide specification addresses a major aspect or material of construction. Examples are the three guide specifications analyzed in this report, which cover cast-in-place concrete, cast-in-place concrete - minor construction, and insulating concrete roof deck system.

Because specifications are intended to cover every aspect of the construction project, comprehensive guide specifications could be massive documents. Rather than the guide specifications being all inclusive, documents such as American Society for Testing and Materials (ASTM) and other standards are referenced, thereby reducing the size and complexity of the guide specifications. If a guide specification contains many requirements, a large number of reference documents may be required. Also, its reference documents will likely contain references resulting in tiering of

references and the creation of a specification hierarchy (spec tree). As is shown in Section 7 of this report, the number of reference documents greatly expands with tiering. An issue which needs to be addressed is, "to what tier level does responsibility of the contractor extend in fulfilling the requirements of the reference documents?"

The Naval Facilities Engineering Command (NAVFAC) is evaluating the need and effectiveness of Navy guide specifications and the need for reference documents in guide specifications. NAVFAC asked the National Institute of Standards and Technology (NIST) to review the uses and advantages of guide specifications in preparing construction specifications and to develop a methodology for determining the appropriateness of each reference document given in a guide specification.

This report presents the results of the NIST study. The report address two major subjects, (1) the need for and the effectiveness of guide specifications, and (2) the need for and the selection of reference specifications. Included in the report is the description and demonstration of the application of a decision rule-based methodology developed for determining the applicability of reference documents. Recommendations on ways to improve the Navy guide specifications and to resolve issues dealing with tiering of reference documents are also presented.

2. OVERVIEW OF SPECIFICATIONS FOR CONSTRUCTION

Three broad classes of specifications have evolved from the development of standardized specification writing practices. They are construction, (military and federal), engineering, and equipment specifications [1][1]. Guide specifications (Section 3) are used for preparing construction project specifications. Equipment specifications are used for purchasing items shipped to the building site, while construction project specifications govern work at the site.

2.1 Purposes of Specifications

Specifications are written contract documents that include detailed requirements for the quality of materials, products, processes, systems and workmanship [2]. The requirements or provisions are the basic units of specifications and standards [3]. Specifications also contain specific qualitative and quantitative information. They may be written using descriptive, proprietary, reference standard, performance, nonrestrictive, or cash allowance requirements [2]. Currently in industry and government, no procurement of goods or services is accomplished without some form of documentation.

2.2 Construction Project Specifications

A construction project specification is a legal document setting forth all the requirements for one project. The construction

[1]Numbers in brackets indicate references listed in Section 10.

project specification does not usually include drawings or symbols, but describes all of the work by statements that augment a drawing which gives the requirements for quality, testing, installation methods, and other factors [4].

Construction project specifications were standardized during World War II as a result of the Army Corps of Engineers need to achieve more effective control of a large number of complex construction projects. Prior to the 1940's, designers transmitted designs for buildings to contractors primarily by drawings. Use of specifications was limited, often they were placed on a corner of a drawing. There were few standards available which could be included in organizing specifications. After World War II, construction project specifications evolved into their current form which has been established by the Construction Specifications Institute [1,5]. Several types of construction project specifications are currently used. They were described and discussed by Lewis [4] and are summarized in Table 1.

Federal construction project specifications are based on guide specifications. If applicable guide specifications are not available (e.g., commercial construction), the construction project specifications could be compiled from previous project specifications, master specifications, manufacture's literature, and accepted office preference [4]. Without available applicable guide specifications or other types of specifications, the

situation requires a complete description of the material and the installation in such terms that only one, or a very small number, of products can be supplied in accordance with the specifications. Clearly, the most desirable approach for preparing contract specifications is to use guide specifications. This approach will facilitate the incorporation of state-of-the-art materials and construction methods.

Construction drawings and construction project specifications are intended to complement each other to cover all conditions, materials and requirements for the project. Drawings indicate quantity and specifications indicate quality [4]. In general, all information regarding fabrication, manufactured quality, type of alloy, mixture design, and similar details of a material should be part of a specification.

There have been a number of attempts to shorten the written specification. Shorter specifications have generally been termed "streamlined specifications", since they try to create a shorter version by eliminating certain words that may not be necessary to the required meaning [4]. The idea is to write the specification in outline form instead of complete sentences. Streamlining of specifications is desirable provided it can be done without loss of meaning. The streamline form serves well in the specification of materials where a simple list may be adequate, but it may not

be suitable for describing methods. The possibility exists of omitting the wrong word, thus changing the meaning [4].

There is an increasing trend towards the use of terms such as "construction manual" or "project manual," where the manual contains all the special information and bidding documents, as well as the actual specification requirements for materials and their installation.

2.3 Master Specifications

Master specifications are frequently used to develop construction project specifications. The aim of the master specifications is to include complete data on every type of material, product, and method of installation that might ever be required. Because wide variations in climate, codes, availability, and preference require differences in materials and installation methods, no particular master specification can possibly be satisfactory throughout the entire country and must be individualized to fit the conditions under which the construction will take place [4].

The primary reason for use of a master specification is to reduce the time required to provide a document that covers the particular project. A great deal of judgment must be used in the selection of the information it contains and in the revisions of an existing master. The master will be different for commercial work, schools, government-financed work, and other types of construction,

so one office may have several kinds of masters, each geared to a particular type of work. Because of differences of opinion among specification writers and Architect/Engineer (A/E) offices, any master should be carefully reviewed by those who will use it; this is true regardless of the origin of the master.

2.4 Some Considerations in Preparing Specifications

Project or construction project specifications are important for controlling the quality of materials and workmanship and the cost in construction projects. Specifications that are incomplete, erroneous, or out-of-date often lead to poor construction, costly design changes, and even disputes and litigation [6]. Although the actual cost of preparing specifications may be less than one-half percent of the total cost of the project, the quality of the specifications can have a major effect on the final cost [6].

At a conference on contract disputes, White [7] reported that the two major causes of disputes were confusion and changes. He stated that confusion results from too little, too much, or unclear information. Changes often result from the need to correct confusing information. He listed the following specification deficiencies that cause confusion and lead to contract disputes:

- Conflicts between sections or between the specifications and the drawings.
- Complicated grammatical constructions which cause interpretation problems.
- Information located in hard-to-find or illogical portions of the document.

- Lack of specific information required to ascertain the type, quality, or importance of a work item.
- Ambiguous and unclear specification intent.
- Extraneous and superfluous information including references to unneeded specifications and standards.
- Inappropriate use or overuse of codes, particularly if codes are not commonly used or are not available in the field.
- Over-specification of methods rather than results.

Many of the problems listed above become magnified when multiple specifications are included in one document. Hard-to-find information, hard-to-understand requirements, and hard-to-attain results in the contract document cause extra administrative and inspection efforts. Information which is repeated in several sections, or which is slightly different in several places, requires a special effort in order to correct the problem. NAVFAC reported [8] that the majority of claims made against the Government result from inconsistencies between, or ambiguities in, specifications and drawings, and, in some cases, within each of them. The American Society of Civil Engineers reported on problems associated with construction project specifications and recommendations for improving the quality of specifications [9-20].

White [7] also reported that deficiencies in project specifications can be avoided by using standard or guide specifications developed in-house or through commercial specification preparation services. Referenced codes and standards can be helpful in minimizing the

length of a contract specification, provided the applicable portions are clearly stated [7].

The architect or engineer who draws up construction project specifications should consider the possibility of legal action resulting from the construction project. Since interpretations by the courts are often different from those intended by the architect/engineer, the specifications must be considered as legal documents that not only tell the contractor what is intended, but what will hold up in a possible court case.

3. GUIDE SPECIFICATIONS

3.1 General Aspects

In a construction project, quality is dependent on proper practices being performed in many stages which include design, procurement of appropriate materials and products, construction procedures, inspection, and testing. Adequate guide specifications can enhance the quality of the work in every stage of the overall construction process. Construction guide specifications are the primary reference documents used by designers in preparing the technical requirements for construction projects [21].

As defined by the Federal Construction Council [22], guide specifications are model construction project specifications that have been prepared and published by a Federal agency to serve as a guide for architects and engineers (both government employees and

professionals in private practice who have been awarded a government design contract) when preparing specifications for a particular construction project. Guide specifications usually cover a variety of situations, and therefore, they must be edited before being applied to a specific procurement.

Guide specifications may contain both prescriptive and performance requirements. In performance specifications, the description of a system is given in terms of its output rather than its parts. Performance specifications usually contain three kinds of statements for each attribute specified: a requirement, a criterion, and an evaluation test. The test must be objective in verifying compliance of different solutions with the relevant criterion. If such a test does not exist for determining that a certain level of performance was achieved, then a performance specification cannot require that level of performance [23]. For this reason, performance specifications do not exist for many requirements in guide specifications. In general, performance specifications describe the end result, whereas prescriptive specifications describe the development of the product [20].

It is the policy of all Federal agencies not to use brand names to describe a product and its characteristics in guide specifications. There may, however, be instances where brand names must be used, such as when there is no other feasible way of describing the essential functional or physical characteristics of a material or

product. Guide specifications are subject to the same general rules as any effective written communications. The purpose of the guide specifications is to provide a basis for project specifications. Because they are read and interpreted by many different people under many different conditions, clarity and readability are essential [24]. Preparation of guide specifications differs from preparation of most other documents in that guide specifications convey a combination of legal, technical, and workmanship requirements with each relating properly to the others [24].

The Federal Construction Council (FCC) Guide Specification Program makes available to all Federal construction agencies, for use on a voluntary basis, a series of Federal Construction Guide Specifications (FCGS) covering the majority of work items encountered on federal construction projects [24]. In most respects, the items of work included in the FCGS program follow MASTERFORMAT (Master List of Section Titles and Numbers) which is published jointly by the Construction Specifications Institute, Inc. (CSI) and Construction Specifications Canada.

3.2 Development and Revision

Many federal and local government agencies produce guide specifications. Many of these guide specifications are prepared by agency employees, but government agencies sometimes use outside help in developing and updating their guide specifications.

In the development of guide specifications by the Federal agencies, the general policy of the Federal government with regard to the nature and form of specifications used for procurement must be followed. The following requirements must be fulfilled regarding the preparation of specifications for acquisition of supplies and services [22]:

1. Agencies shall specify needs in a manner designed to promote full and open competition.

2. Agencies shall develop specifications and purchase descriptions using market research in a manner designed to promote full and open competition with due regard to the nature of the supplies or services to be acquired.

3. In solicitations, agencies shall include specifications and purchase descriptions that permit full and open competition, and include restrictive provisions or conditions only to the extent necessary to satisfy the minimum needs of the agency or as authorized by law.

4. Agencies shall prepare specifications and purchase descriptions which reflect the minimum needs of the agency and the market available to satisfy such needs. Specifications and purchase descriptions may be stated in terms of: (i) function so that a variety of products or services may qualify; (ii) performance including specifications of the range of acceptance characteristics or of the minimum acceptable standards; or (iii) design requirements.

Acquisition policies and procedures shall require descriptions of agency requirements, whenever practicable, to be stated in terms of functions to be performed or performance required.

3.2.1 Federal and Commercial Guide Specification Developers

Two major Department of Defense (DoD) developers of guide

specifications are the U.S. Army Corps of Engineers (COE) and the Naval Facilities Engineering Command (NAVFAC). Separate construction guide specifications are developed and maintained by each of these military services. They have prepared and maintained construction guide specifications that have been used successfully on construction projects for many years. The COE distributes, and maintains all of its construction guide specifications through their Huntsville Division. Some guide specifications are produced at Huntsville, Alabama, but most are prepared by other sources, with the Huntsville Division providing coordination and quality assurance. The COE districts and laboratories prepare specifications pertaining to a particular technical area when they are recognized leaders in that area. In some cases, specifications are prepared or updated under contract when COE staff resources are not available. NAVFAC guide specifications are developed and maintained by its six Engineering Field Divisions (EFDs). Most NAVFAC guide specifications are prepared and maintained by NAVFAC project specifications personnel or, infrequently, through contracts with industry. NAVFAC headquarters criteria managers maintain close ties with a criteria manager at each EFD in order to direct and coordinate development and maintenance of the NAVFAC guide specifications.

The NAVFAC Guide Specifications Manual [8] contains policy, standards, and detailed instructions for the preparation of NAVFAC guide specifications and Federal construction guide specifications.

Also presented, are procedures for the coordination of new, revised, and amended guide specifications within the Naval Facilities Engineering Command, the Building Research Board of the National Research Council, and selected areas of industry. The manual is intended for use in instructing new NAVFAC specification architects and engineers, and as a reference source for those more experienced. The manual [8] is a comprehensive document describing the development of the NAVFAC specifications system; the current status of the NAVFAC criteria program; information about other guide specification programs; development, maintenance, and coordination of criteria; principles of specification writing; format; use of reference documents; composition of a guide specification; and changes, amendments, and revisions.

Two commercially available guide specifications are recognized as being the industry leaders [21]. The American Institute of Architects Service Corporation (AIA/SC) is associated with the American Institute of Architects and has MASTERSPEC as the registered trademark of its construction guide specification system. MASTERSPEC was developed primarily to aid practicing architectural and engineering (A/E) firms in the compilation of project specifications. The latest edition of this specification, MASTERSPEC 2, is sold through subscriptions by the AIA/SC. The General Services Administration (GSA) modified MASTERSPEC to meet its needs.

The other leading industry guide specification system, SPECTEXT, was developed by the Construction Sciences Research Foundation (CSRF) under the auspices of the Construction Specifications Institute (CSI). SPECTEXT is developed and updated by technical committees with coordination from CSI and is marketed by CSI.

3.2.2 Contents and Format

Guide specifications are typically organized in a three-part format. The first part addresses general information such as references, description of work, submittals, delivery, and storage; the second part is devoted to requirements for materials and products and for the area of work being addressed; and the third part covers the execution of work. In most cases, the execution part covers installation requirements, although it could address processes and procedures. The three-part format has been widely accepted by most guide specification users and has been adopted by COE and NAVFAC in the preparation and revision of their specifications [21]. The organization of a specification or a standard determines whether provisions can be found reliably and efficiently by the reader [25].

The guide specification systems all follow the CSI 16-division format [21]. This format system is jointly sponsored by CSI and Construction Specifications Canada and is accepted by industry in both countries. It provides a uniform approach to the organization of construction requirements. Division 1 of the

16-division format contains general contract requirements, and Divisions 2 through 16 contain requirements for specific technical areas. Each division is divided and subdivided into smaller sections as necessary. SPECTEXT is the only system that exactly follows the designated CSI subdivision identification scheme. The COE and NAVFAC currently utilize a numeric system to categorize their guide specifications. SPECTEXT and GSA use an alphanumeric system and MASTERSPEC does not use any numbering system beyond the major specification section identification. In comparing the various systems, only minor differences exist in specification numbering and organization.

Technical notes are used by all guide specification systems to clarify and advise the specification writer when there are wording choices to make. These notes also provide insight into the intended use of the reference specifications. The COE and NAVFAC put technical notes at the end of specifications, and they are cross-referenced to the text of the specifications by capital letters placed in the right-hand margin of the specification. Technical notes in MASTERSPEC are provided throughout the body of the specification. More editing is required with this system than with the DoD systems and, thus, can be cumbersome for the specification writer. SPECTEXT has its technical notes in a technical aid series that complements each specification. The COE and NAVFAC provide design aid through technical manuals, engineering pamphlets, and other documents, while MASTERSPEC and

GSA provide evaluation sheets at the end of each specification. The evaluation sheets provide the designer and specification writer with a narrative on each guide specification, but the narratives are generally much less detailed than the design aids provided by DoD.

Construction by DoD covers a wide spectrum of facility requirements applicable to the design and construction of everything from child care centers to large dams [21]. Specification systems for the military services must be capable of addressing requirements for residential, industrial, and heavy civil projects. MASTERSPEC and SPECTEXT do not fully cover construction requirements for large facilities such as dams and airports. These industry guide specification systems do cover residential, commercial, and light industrial construction.

3.2.3 Updating of Specifications

The major specification systems update their material on a planned schedule. Changes are made as needed such as those resulting from a revision of a major reference document or a change in a product. The COE and NAVFAC review and update (rewrite) their guide specifications on a five-year cycle. Each of their specifications are reviewed by the beginning of the third year to determine if updating is required. If necessary, the specifications are revised and reissued. In cases of minor revisions, the COE and NAVFAC issue notices and amendments, respectively, instead of a

complete rewriting of the guide specification. Both MASTERSPEC and SPECTEXT are reviewed on a three-year cycle and are revised if necessary. Major changes to the specifications are made immediately. All changes are issued as a complete specification update and not as a notice or amendment.

The average age of major specification systems reported in 1985 were: 1.7 years for COE, 3.6 years for NAVFAC, 2.0 years for MASTERSPEC, and 1.9 years for SPECTEXT [21]. The average age of a specification reflects its actual state as opposed to the proposed updating. The ages of the specifications were often found to differ from that which would be expected from the system's established updating cycle [21]. When determining the age of a specification, it was assumed that all needed changes were incorporated into the specification whenever a notice or amendment was issued.

3.2.4 Proprietary Products and Systems in Specifications

The Military Services use specifications that are essentially nonproprietary and rely on detailed technical descriptions to describe the materials, products, and the area of work being addressed. Not all guide specification systems utilize nonproprietary or generic specifications. Proprietary names are widely used by MASTERSPEC, thus, enabling elimination of much wording in specifying a desired product. In the GSA-modified version of MASTERSPEC, the proprietary names have been deleted and a lower level of detail exists in the technical descriptions than in those of the DoD

specifications [21]. SPECTEXT does not specify proprietary products but makes provisions to insert them in lieu of detailed descriptions. DoD use of, and subsequent compliance with, Federal Acquisition Regulations requires nonproprietary specifications with sufficiently detailed technical descriptions to permit free and open competition. Not all existing commercial specification systems meet these DoD requirements.

3.2.5 Concluding Remarks

In closing this section on guide specification development, the following quote from Military Standard 490A [26] summarizes the importance for clear and concise written specifications.

> "The paramount consideration in a specification is its technical essence, and this should be presented in language free of vague and ambiguous terms. Using the simplest words and phrases will best convey the intended meaning. Inclusion of essential information shall be complete, whether by direct statements or references to other documents. Consistency in terminology and organization of material will contribute to the specification's clarity and usefulness. Sentences shall be as short and concise as possible. Punctuation should aid in reading and prevent misreading. Well-planned word order requires a minimum of punctuation. When extensive punctuation is necessary for clarity, the sentence(s) shall

be rewritten. Sentences with compound clauses shall be converted into short and concise separate sentences."

3.3 Current Use of Guide Specifications

As mentioned previously, the two most widely used guide specification systems are MASTERSPEC, and SPECTEXT. These two systems are primarily intended for private sector use but, in some cases, are used for public sector projects [21]. For example, (see Section 3.2.1), GSA adopted and modified MASTERSPEC for use in their construction projects. The costs associated with reworking the MASTERSPEC by GSA were relatively small.

All major specification systems use a variety of media to communicate their product. The Military Services and the commercial systems use printed text as their prime medium [21]. Both distribute their specification on flexible (floppy) disks for retrieval by microcomputers. In 1985 the Military Services relied largely on the printed text for distribution of the guide specifications [21].

The COE guide specifications are actively maintained for preparing specifications for new military construction projects [27]. In a 1986 study on guide specifications for small projects, COE's Huntsville Division [28] reported that, regardless of the quality of COE guide specifications for regular new military construction, they are not fully meeting the needs for small projects which

include major maintenance and repair contracts. Specifications should be appropriate for the intended use and they should be easy to maintain. In the past, there were complaints by contractors that the use of DOE Guide Specifications for maintenance and repair projects produced specifications that were too long and complex, and required submittals that were inappropriate for the type and value of the maintenance and repair contracts [27]. For small projects, the volume of specifications should be minimized without sacrificing the essential quality requirements [27]. Government agency guide specifications are designed to be edited and included in project specifications [2]. Editing requires some modification such as adding and deleting requirements to provide appropriate project specifications. It is far more efficient to edit guide specifications than to write new statements of requirements for each particular project.

3.4 Advantages of Using Guide Specifications

Guide specifications provide a centralized source for most of the information needed in the development of particular project specifications. This saves preparation time, reduces preparation costs, and improves comprehensiveness and quality of the requirements [6]. Automated techniques can further improve the process. The use of guide specifications does not, however, eliminate the need to have an experienced professional prepare or assemble the final document.

Some of the advantages of using guide specifications are given below [4,5,6,9,15,24,27,29]. For convenience, they are grouped under the headings of speed, efficiency, and cost-effectiveness; quality and consistency; and ease of use and legal liability.

1. Speed, Efficiency, and Cost-Effectiveness

It is faster, more efficient, and cost-effective to produce a contract specification by editing a guide specification than by writing a new set of requirements for each project because it:

- minimizes repetitive work
- reduces the technical effort and time
- reduces the administrative effort and time
- reduces dependency on highly-qualified specification writers
- minimizes duplication in the preparation and maintenance of construction project specifications
- reduces costs in developing individual project specifications
- facilitates updating of specification data
- ensures that the specifications used represent the current market for acceptable materials and equipment
- unifies office practices
- reduces proofreading time when word processing systems are used
- aids automation of specification preparation

2. Quality and Consistency

Contract specifications produced by editing a guide specification, rather than by writing a new set of requirements for each project,

are generally of higher and more consistent quality, and less likely to have errors because a guide specification:

- o serves as a checklist of requirements and provisions to help the specification engineer minimize errors and omissions
- o provides more consistent requirements
- o uses national standards
- o enhances the selection of appropriate referenced specifications and standards
- o provides methods to determine reasonable compliance
- o provides a system for improvement of specifications by using feedback from the field
- o provides contract specifications that have been proven in successful construction
- o requires the most acceptable construction/installation techniques, including appropriate safety measures
- o uses up-to-date materials, components, and systems
- o avoids materials or products that are obsolete or unavailable, or have been proven inferior during other projects
- o avoids obsolete or unavailable materials or methods
- o incorporates new technology
- o increases use of professional expertise in the development of project specifications
- o forms a foundation for training quality assurance evaluators

3. Ease of Use and Legal Liability

The preparation of contract specifications by editing a guide specification produces products which are easier to use and less likely to lead to disputes and litigation because it:

- o provides a uniform terminology

- o gives greater uniformity in format and technical requirements
- o enhances sharing of requirements with other organizations
- o avoids delays in project development
- o helps the contracting office monitor the quality of work
- o helps contractors in bidding on work from more than one installation or area
- o reduces exposure to liability
- o provides a good foundation for settling claims

3.5 Assessment of DoD Guide Specifications

In 1985, Moore, Fagan and Cable [21] conducted a study to address whether either a commercial guide specification system alone, or in conjunction with existing DoD construction guide specification systems, could provide a more effective means for specifying DoD construction requirements. They reported that no major dissatisfaction existed with either the COE or the NAVFAC system. They also recommended that DoD should maintain a construction guide specification system [21]. In their report, the term "guide specification system" encompassed more than just the guide specification. The term included the supporting materials, documents, and automated systems that made the construction specifications work. They also reported that industry and government were supportive of the existing DoD guide specifications [21].

Moore, Fagan and Cable [21] suggested several improvements of the DoD guide specifications. One of these addressed a more effective

means of defining quality by listing three or more manufacturers for each product rather than relying solely on nonproprietary specifications. Further, it was believed that commercial guide specification systems have positive attributes that the DoD guide specifications should emulate, particularly streamlined wording. It was suggested that the separate COE and NAVFAC systems could be merged into a single Tri-Service specification system. There was expressed a need for DoD to simplify and streamline the guide specifications, to eliminate the use of MIL specifications and FED specifications, to improve the distribution of guide specification updates and revisions, and to have guide specifications made available in a variety of word processing formats [21].

The major problem with the current COE and NAVFAC guide specification systems appears to be the distribution of guide specifications, guide specification revisions, and supporting documents from the specification writers to the field offices and private users [21]. Many users are unaware of current revisions or how to obtain them. Because of lack of uniformity and consistency in the type and availability of word processing systems throughout DoD offices, there is a need to make the DoD guide specifications available in multiple word processing formats [21].

There were some reported advantages for DoD to adopt a commercially available construction guide specification system. However, the reported disadvantages outweighed the advantages and thus

adoption did not appear to be beneficial to DoD. The reported advantages were [21]:

1. Provide DoD with a more streamlined wording of the construction guide specifications.
2. Movement toward an industry-wide consensus construction guide specification.
3. Free resources to work on improving Service-specific specifications.
4. More rapid adoption of new technologies into the design process.
5. Decrease the barriers that a contractor faces when first entering into the government market.

The reported major disadvantages in adopting a commercially available guide specification were [21]:

1. Payment of annual subscription fees to the system developer.
2. Problems with construction contract enforcement because provisions for minimum level of quality may not be closely defined in the specifications.
3. Revisions would have to be made by DoD to implement a commercial guide specification system.
4. The detailed and numerous references that support the guide specifications would have to be revised.
5. Required retraining and familiarization of DoD personnel in the use of the commercial system.

DoD construction specifications (both guide specifications and project specifications) have been criticized for being "too wordy" [21]. The guide specifications prepared by DoD have become more voluminous over the years from attempts to include requirements for more situations. These modifications have often resulted in including more words than are needed to convey the meaning of the

specifications in an attempt to close "loopholes". It has been recommended that the DoD construction guide specifications be streamlined by eliminating excess wording [21]. Streamlining would improve the quality of the DoD construction guide specifications, and it was estimated that the length of the existing specifications could be reduced by 30 to 40 percent [21].

4. COMPARISON OF NAVFAC AND OTHER FEDERAL GUIDE SPECIFICATIONS

In preparing this report, a specific NAVFAC guide specification was compared to similar specifications from other Federal agencies to assist NAVFAC in determining if significant changes should be considered in their guide specification structure and requirements. A comparison was made of the NAVFAC, COE, National Aeronautical and Space Administration (NASA), and Veterans Administration (VA) guide specifications for cast-in-place concrete. The four guide specifications were:

NFGS-03300, (NAVFAC); 30 pages, including notes.
CEGS-03300, (COE); 28 pages, including notes.
NASA SHELF MASTER Section 03305, Broad scope; 43 pages.
VA Master Specification Section 03300; 42 pages, double spaced.

All four guide specifications followed the CSI format with regard to having three major parts -- general, products, and execution. The format, however, within each part was somewhat different in each of the guide specifications. The NASA Guide Specification

provided more information, details, and options than the other guide specifications, and thus was longer than the others. In addition, the referenced specifications are not repeated in the individual NASA guide specifications, but are listed in another section. Section 03002 of NASA's guide specifications listed 162 reference specifications pertaining to concrete.

The COE, NAVFAC, and VA guide specifications were similar with regard to the text, a major portion of each being in the form of paragraphs. The NASA guide specification differed in that many of the requirements and provisions were stated in short statements. However, other requirements and provisions were in paragraph form similar to the other three guide specifications.

All of the guide specifications contained essentially similar provisions and reference specifications, but differed somewhat in emphasis on particular issues. For example, the COE guide specification provided more guidance about evaluating concrete and investigating low-strength test results. With regard to reference specifications, there were some differences between the four guide specifications. Both NASA and VA referenced ACI 318, Building Code Requirement for Reinforced Concrete [30], but this document was not referenced in the COE and NAVFAC guide specifications. The ACI document covers the proper design and construction of reinforced concrete and is written in such a form

that it may be incorporated or adopted by reference in a general building code.

4.1 Information from NASA Report

Reference No. 6 which was published by NASA in 1980, gives general information about the COE, NAVFAC, GSA, and NASA guide specifications. This information is summarized in the following paragraphs.

The COE guide specifications have evolved over a number of years and cover Divisions 2 through 16 of the CSI MASTERFORMAT. Division 1 was omitted because it was considered inappropriate for Army construction needs. The COE guide specifications are primarily intended to assist contractors in preparing project specifications. These guide specifications are available for public use since they have application to civilian building needs for similar types of buildings and structures. Project specifications are prepared by editing, deleting, filling in blanks, and adding appropriate sections to the guide specifications.

In 1971, NAVFAC decided to consider automating the production of specifications. A fully automated system is now in operation. The NAVFAC specifications system is applicable for most types of construction from general public works to hospitals. The guide specifications cover all 16 divisions of the CSI MASTERFORMAT, although there are differences in section numbers and the use of section subheadings. These differences were typical for all the

master specification systems reviewed [6]. There is a guide and index for using the system, and the specifications are available to the public upon request.

In 1988, NAVFAC issued a compilation [31] of section numbers and titles of guide specifications offered by several Federal agencies, AIA, and CSI. This document was produced to encourage criteria sharing, promoting technical interchange, and saving resources.

The Public Buildings Service (PBS) of GSA produces master specifications that are used for Federal office building construction. All 16 divisions of the CSI MASTERFORMAT are included in the master which is updated on a two-year cycle. Each section of a specification generally follows the three-part CSI section format, except that the headings for each part are not used. The GSA system follows the guidelines and procedures of the Federal Construction Council Guide Specification Program. The specifications are developed to guide contractors in preparing project specifications. Project specifications are prepared by editing, deleting, filling in blanks, and adding appropriate sections to the guide specifications.

In the late 1960's, NASA developed a new specifications system applicable to a large number of ground-based support facilities, from high-rise gantry towers and sophisticated test facilities to

warehouses and offices. The computer-based system of specifications writing, developed by NASA's Langley Research Center, contains a comprehensive central catalog of master specification sections which are applicable to many types of construction. This computer-based system is accessible to all NASA centers. Using the SPECSINTACT system, designers for any project may retrieve relevant sections of text from computer storage and modify them to satisfy the needs of a particular project. In this process, engineers can concentrate on modifying the basic master specifications instead of creating entirely new specifications. Since the master specifications are developed by a single center, only one professional team is needed to monitor the use of the system and to incorporate new and cost-effective building technologies. Recently, the NASA field centers placed SPECSINTACT on word processing equipment. Each field center has a self-contained mini-computer equipped with input unit, disk storage, and printer output. The SPECSINTACT system is organized according to the 16-division CSI MASTERFORMAT system. Another division was added, Number 17, on welding/brazing/soldering, to meet special needs. There are plans to eliminate this division and incorporate the information into other divisions.

4.2 Computerized Construction Criteria

In a recent development during 1987 and 1988, the National Institute of Building Sciences completed its Construction Criteria Base, a library of Federal construction guide specifications,

standards, and manuals that is contained on a single compact disk. The Construction Criteria Base (CCB) currently includes the entire text of more than 50,000 pages of construction specifications issued by NAVFAC, the Army Corps of Engineers, NASA, and VA. The disk's full-text and retrieval software enables users to locate specific words in any database within a few seconds. Ten different word processor formats are supported for output.

The CCB is fully updated and indexed quarterly. Also included in the CCB is a NASA and NAVFAC developed specification processing system designated SPECSINTACT which has been adopted by the Navy, NASA, Corps of Engineers, and other federal agencies. Eventually, the CCB will also contain the complete construction criteria of the VA, the Bureau of Reclamation, the Department of Energy and GSA.

5. REFERENCE SPECIFICATIONS AND STANDARDS IN GUIDE SPECIFICATIONS

It is common practice in construction project specifications to require various materials, products, and assemblies to conform to standards and criteria stated in other publications. When referenced, these publications become, in essence, a part of the construction contract [22]. Commonly referenced documents include both nongovernment and government standards. The Federal Acquisition Regulation (FAR) allows both private and government standards to be referenced in Federal construction specifications. All Federal construction agencies have adopted the policy given in Circular A-119 (October 26, 1982) of the Office of Management

and Budget. This policy states that when both a government and a nongovernment standard exist for the same item, the more suitable of the two should be referenced, and that if both are equally suitable, the nongovernment standard should be cited [22].

5.1 Need and Use

There are many similarities among construction projects. These similarities pertain to the materials and products, to processes and practices to accomplish the work, and to needed requirements for levels of quality and performance. Writing a series of completely independent specifications for separate projects would result in much duplication. This duplication can be reduced or avoided by placing the common requirements into separate specifications which can be referenced for each project [1].

All major guide specification systems use established national reference specifications and standards to efficiently communicate material and construction requirements [21]. Reference specifications also are used for workmanship standards [32]. The two major sources of reference standards used are those issued by the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) [21]. ASTM and ANSI standards are recognized worldwide as among the leading industry sources of reference standards [21]. The Military Services and the commercial construction specification systems extensively refer to ASTM and ANSI standards. These standards are familiar to the

construction industry and present few communication problems. Until recently, the Military Services frequently used Federal (FED) and Military (MIL) specifications or standards as reference standards in their guide specifications. The Military Services have recognized the shortcomings of the FED and MIL SPECS and have decided to minimize their use in guide specifications [21]. In recent years, DoD has encouraged the use of nongovernment voluntary consensus standards throughout the military services. DoD demonstrated its high regard for ASTM standards by adopting more than 2000 of them by 1988 [29]. Many more nongovernment standards are used by DoD without having been formally adopted.

There are many reasons why reference standards and specifications are used in guide specifications. They constitute one of the major communication and control mechanisms for the building industry and influence appreciably the design and quality of the constructed or manufactured product [33,34]. A major purpose of the referenced documents is to control the quality of the material or product and to minimize the size and complexity of the project specifications and procurement documents. Reference standards and specifications are used because they:

- are an effective communications tool
- are universally accepted
- are universally understood
- are cost-effective
- offer options for various levels of performance

- provide for standardization of manufactured products
- provide for standardization of fabrication procedures at the job site
- facilitate ordering of materials and products that are of specified quality
- provide established test methods to measure the quality of products and materials
- provide specifications for quality of materials, products, and workmanship
- provide standardized procedures for interpretation and analysis of test data
- provide for standardized definitions of terms relating to materials, products, and workmanship
- provide a mechanism for technology transfer
- provide a basis for economic decisions with regard to materials, products, and workmanship

It is NAVFAC policy that the number of reference documents included in their guide specifications be the minimum necessary to assure that the minimum essential functional requirements of the Government are satisfied [8]. By Act of Congress, the number of reference documents in all Government procurement specifications are required to be reduced to the minimal amount needed [8]. Therefore, the need for each reference document in a NAVFAC guide specification should be challenged by specification reviewers. Nationally recognized industry and technical society specifications and standards should be used to the maximum extent possible. In the selection of a reference, the most adequate document should be used to assure that requirements are compatible with current

state-of-the-art construction materials and practices, industrial practices, and manufacturing resources.

In order to reduce the proliferation of reference documents, only the portions needed should be referenced instead of citing the entire document [8,24]. Following this procedure and using only needed references will facilitate the streamlining or reduction of the tiering of specifications (spec tree). When necessary to reference an entire document, the reference should be followed with notations as to the specific chapters, sections, paragraphs or other subdivisions, which apply to the guide specification. In this case, the listing is considered to comprise less than a substantial portion of the document. As a result, this practice decreases substantially the volume of reference material that the contractor and contract administrator must study and act upon to comply with the terms of the contract [8]. The reference specifications must be studied thoroughly, especially when several options exist in the choice of materials or equipment, in order to select and state in the guide specification the options which are to be provided.

Because standards are constantly revised and reissued, it is difficult for agencies to ensure that their guide specifications reference the correct edition of each standard [22]. The latest revision is usually, but not necessarily, the proper edition to be referenced. The problem of referencing the latest revision of

standards in guide specifications is approached in different ways by the different agencies. For example, NAVFAC does not attempt to keep the references in each individual guide specification up-to-date [22]. Instead, NAVFAC publishes a quarterly listing of documents, both government and private, currently referenced in Navy criteria for facilities. Other agencies, such as the COE and NASA, use other procedures to keep the referenced standards up-to-date.

Blackmon [27] gives the following guidance for updating guide specifications:

1. The current edition of reference specifications, standards, and codes should be included as well as the appropriate classes and types of materials and products specified in each reference document.

2. The reference specifications should reflect the current market for materials, products, equipment, and processes.

3. The reference specifications should include those materials, products, equipment, and processes that have shown to be acceptable and specifications deleted that have not produced good results in this regard.

Even though considerable effort is devoted to keeping references up-to-date in guide specifications, these efforts usually are not totally effective. Thus, agencies advise those using their guide specifications to check the references carefully in construction project specifications to ensure that the proper editions have been referenced [22]. Reference specifications used by a specification writer should be available in the office. These

specifications and standards are needed to assure that materials or installation procedures specified using the specifications and standards, are satisfactory and pertinent to the project [32].

6. DECISION RULES FOR SELECTION OF REFERENCE SPECIFICATIONS AND STANDARDS

Decision rules were developed in this study in order to determine the need for reference specifications. The decision rules were also intended for use in deciding if particular reference specifications could be deleted, others added, or if only limited portions should be referenced instead of the entire document. The decision rules were applied to three example construction guide specifications. However, they are believed to be applicable to all construction guide specifications. They are intended for use in selecting the most appropriate reference documents which adequately address the needed criteria, requirements, and provisions. They also can be used to avoid conflicting, confusing, ambiguous, unobtainable, and unenforceable requirements in the guide specifications.

6.1 Decision Rules

Decision rules for reference specifications and standards were developed in this study. The rules are expressed in the form of questions in the following:

1. Are the reference specifications and standards applicable (i.e., do they address the provisions given in the guide specifications)?

- are correct specifications and standards referenced?

- can the reference specifications and standards be deleted with minimal but acceptable risk occurring?

- is the coverage of requirements complete?

- is there a need to add other applicable reference specifications and standards?

- are requirements adequate for their intended purpose?

2. Do the reference specifications and standards provide for state-of-the-art practices or are they obsolete?

   - are the latest revisions of the reference specifications and standards incorporated in the guide specification? (It is the responsibility of the specifier to determine which revision is to be used).

   - are obsolete reference specifications and standards used?

   - should other reference specifications and standards be used?

3. Are there inconsistencies in the information provided in the reference specifications and standards?

   - are there conflicting statements?

   - are there conflicting provisions?

   - are there confusing statements?

   - is there duplication of information and requirements?

4. Are the requirements in the reference specifications and standard enforceable?

   - are the requirements explicitly stated or merely implied? (If merely implied, they are not likely to be enforceable).

5. Do the reference specifications and standards contain choices other than those in the guide specification?

6. Do the reference specifications and standards void provisions specifically stated in the guide specifications?

7. Are minimum requirements for quality in reference specifications and standards so restrictive that they exclude most commercially available materials, or are they so low that nearly anything produced can meet them? (Reference specifications and standards often define quality in terms of minimum requirements).

   - are options given in the guide specifications?

8. Do reference specifications and standards create a mixture of prescriptive and performance requirements in the guide specification? (Prescriptive and performance requirements should not be mixed for specific provisions).

9. Are reference specifications and standards properly designated in the guide specifications?

10. Are any of the reference specifications and standards redundant, (e.g., do two or more of them cover the same requirements)?

    - do the reference specifications and standards create duplication within the guide specifications?

11. Are the reference specifications and standards compatible with provisions in the guide specification and in other reference specifications and standards?

    - are there conflicting statements?

    - are there confusing statements?

    - are ambiguities created in the guide specification?

    - do the requirements of a reference specification or standard conflict with the requirements of another reference specification or standard?

    - do requirements listed within other reference specifications or standards contain qualifications that will contradict requirements of any other reference specification or standard?

12. Is it necessary to reference an entire document or will specific portions of the document provide the necessary requirements?

    - are more requirements referenced than necessary?

    - are only the needed requirements referenced?

- is the reference document serving as a guide? (If so it should be stated).
- are the requirements excessive?
- are unnecessary explanations for requirements included?

13. Are the requirements in the reference specifications clear and unambiguous?

14. Do reference specifications cover a lack of specific requirements with general references to codes and standards?

6.2 Application of Decision Rules

The decision rules for selection of reference specifications were applied to the three NAVFAC guide specifications NFGS-03300, Cast-In-Place-Concrete; NFGS-03302, Cast-In-Place-Concrete (Minor Construction); and NFGS-03501, Insulating Concrete Roof Deck System. The completeness of the decision rules were evaluated by analyzing them against the need for the reference specifications in the three guide specifications. The three guide specifications were also reviewed to determine if the criteria and provisions were adequately addressed.

6.2.1 Procedure for Applying Rules

The guide specifications were reviewed one paragraph at a time. The corresponding reference specification or specifications, if any, included in that paragraph were reviewed along with the decision rules. The decision rules were applied to the reference specifications in that paragraph and the paragraph was reviewed for criteria, provisions, clarity, and verbosity. In addition,

related paragraphs in the guide specification that may have similar criteria and provisions, were reviewed to identify the presence of any conflicting, confusing or inadequate statements.

6.2.2 Comments on Reference Specifications in Guide Specification NFGS-03300

Most of the reference specifications in NAVFAC Guide Specification NFGS-03300, Cast-In-Place Concrete, were issued by the American Concrete Institute (ACI) and the American Society for Testing and Materials (ASTM). The nine ACI publications were fairly long, 17 to 49 pages, whereas the 36 ASTM publications were fairly short, 2 to 13 pages, with most ASTM publications 5 pages or less.

The reference ACI publications in NFGS-03300 contain extensive information such as would be expected in standard practices. The reference ASTM publications in NFGS-03300 contain, in general, material and product specifications. Thus, in applying the decision rules to reference ACI publications, it was noted that, in some cases specific requirements were stated such as "minimum coverage in ACI 301[2]" or, "the surface of concrete shall not vary more than the allowable tolerances of ACI 347[3]".

---

[2]Specifications for Structural Concrete.

[3]Recommended Practice for Concrete Formwork.

The ASTM material and product specifications were directed toward specific requirements such as coarse aggregate sizes given in ASTM C-33[4], and cement types given in ASTM C-150[5] and ASTM C-595[6]. The Guide Specification referenced 36 ASTM specifications. It is noted that the referenced ACI specifications also referred to many of the same ASTM specifications included in the Guide Specification.

6.3 Findings From Decision Rule Application

The major finding from decision rule application was that the reference specifications selected for the three NAVFAC Guide Specifications (NFGS-03300, NFGS-03302, and NFGS-03501) were in general, the best available. All the reference specifications were considered necessary, and there were very few instances of conflicting or confusing provisions attributable to the use of the reference specifications. The most prevalent problem with the reference specifications was that in many cases they were not the latest revision. In NFGS-03300, 28 of the 50 reference specifications were not the latest revision. In the Technical Notes section of NFGS-03300, it is stated that the latest issue of the applicable publications shall be used only after reviewing the proposed document to assure that it will provide a facility meeting the minimum essential requirements of the Government.

---

[4]Specifications for Concrete Aggregates.

[5]Specifications for Portland Cement.

[6]Specification for Blended Hydraulic Cements.

This may be difficult for a specifications writer, especially if review is needed for reference specifications such as ACI 301, Specifications for Structural Concrete for Buildings; ACI 304, Guide for Measuring, Mixing, Transporting, and Placing Concrete; and ACI 315, Details and Detailing of Concrete Reinforcement. It would be better if the reference specifications could be kept up-to-date in the guide specifications. If a system for doing this could be developed, it would provide for having the latest revisions included in the reference specifications. In the description of the work given in NFGS-03300, it is stated that the advisory provisions in the referenced ACI publications shall be considered mandatory. Therefore, since the referenced ACI publications contain many requirements and provisions, it would be better if a concrete technical expert, rather than a specifications writer, conduct the review.

Other findings from the decision rule application and review of the three Guide Specifications are as follows. In a section on shop drawings for formwork, ACI 347 is referenced. This ACI Recommended Practice for Concrete Formwork is a 37-page document which presents recommended practices for formwork and suggests criteria for assuring proper performance. Engineers and architects should recognize that this standard, ACI 347, is not written in specification language and should not be used as a reference specification. However, an understanding of its recommendations by engineers and architects would greatly assist them in the

preparation of specifications.

In the section on aggregates in NFGS-03300, there is the following requirement, "Aggregates shall not contain any substance which may be deleteriously reactive with the alkalies in the cement." This requirement is not as exactly stated in ASTM C-33[4]. Since it does not state how the substances are to be identified, or give limits to the amount of substance permitted, this requirement is not enforceable. Methods for detecting potential alkali reactivity of aggregates have been proposed, but do not provide quantitative information to the degree of reaction to be expected or tolerated in service. Methods for evaluating potential reactivity of an aggregate are given as nonmandatory information in an appendix of ASTM C-33[4]. There are two ASTM test methods, C-227[7] and C-441[8], to test for potential alkali reactivity of cement-aggregate combinations, and effectiveness of admixtures in preventing excessive expansion of concrete due to alkali-aggregate reaction, respectively.

In the section on contractor-furnished mixture design, it is stated that the chloride content shall not exceed one percent. It is noted that in ACI 222R-85, Corrosion of Metals in Concrete, the

---

[7]Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).

[8]Test Method for Effectivenss of Mineral Admixtures in Preventing Excessive Expansion of Concrete to the Alkali-Aggregate Reaction.

maximum allowable chloride content is 0.2 percent by weight of the amount of cement. A conflicting provision was also noted in the section on reinforcement in NFGS-03300 due to referencing both ACI 301[2] and ASTM A-616[9]. ACI 301[2] states an exception from ASTM A-616[9] that all bars shall be bend-tested and shall meet the bend test requirements of axle steel reinforcing bars, Grade 60, ASTM A-617[10]. It is noted further that ACI 301[2] has many exceptions from specifications it references.

In the section on mechanical reinforcing bar connectors in NFGS-03300, ACI 301[2] is referenced. ACI 301[2] does not contain requirements for bar connectors. The only reference to connectors is, "Mechanical connections for reinforcing bars may be used subject to acceptance."

In the section on liquid chemical sealer-hardener compound in NFGS-03300, the following two requirements are given: (1) compound shall be magnesium fluosilicate which when mixed with water seals and hardens the surface of concrete, and (2) compound shall not reduce the adhesion of resilient flooring, tile, paint, roofing, waterproofing, or other material applied to concrete. With regard to the first requirement, the description of the material is not adequate and the proportion of material to water is not

---

[9]Specifications for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement.

[10]Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement.

given. The second requirement does not state how the reduction in adhesion is determined.

In the section on forms in NFGS-03300, reference is made to ACI 301[2]. It would be appropriate to also reference ACI 347 for guidance in this section, since ACI 347 is a recommended practice for formwork.

In comparing NFGS-03300 with NFGS-03302, twelve of the specifications referenced in NFGS-03302 were later revisions of specifications referenced in NFGS-03300. In order to provide consistency in the guide specifications, reference specifications with the same issue date should be used. Also, with regard to consistency, the same reference specification should be used for the same requirement in different guide specifications. For example, for the requirement regarding vapor barriers, NFGS-03300 refers to ASTM D-4397[11], while NFGS-03302 refers to ASTM C-171[12]. With regard to curing of insulating concrete in NFGS-03501, Section 3.5.5.2 in the guide specification states that under normal conditions roofing may begin to be applied in 3 days. Paragraph 13 in NFGS-03501 in General Notes states that the insulating concrete should be covered with subsequent roofing materials soon after being allowed to cure for a minimum of 10 days.

---

[11]Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.

[12]Specification for Sheet Materials for Curing Concrete.

7. TIERING OF SPECIFICATIONS

The number of reference specifications in a guide specification may vary depending on the scope and extent of the work specified. As an example, the three guide specifications included in this study, NFGS-03300 (January 1988), Cast-In-Place Concrete; NFGS-03302 (October 1986), Cast-In-Place Concrete (Minor Construction); and NFGS 03501 (April 1987), Insulated Concrete Roof Deck System; contain 50, 31, and 9 reference specifications, respectively. The reference specifications in the guide specifications are referred to as applicable publications. In appropriate cases, the guide specifications state that advisory provisions in designated referenced voluntary consensus publications (specifications or standards) shall be considered as mandatory as though the word "shall" has been substituted for "should" wherever it appears. In most cases, each reference specification in the guide specification lists applicable documents which form a part of the reference specifications to the extent referenced. This process is repeated on several levels in that the reference specifications in the guide specification also contain reference specifications. Thus, there are tiers of specifications which pertain to each level of referenced specifications. Studies have revealed that, in the absence of positive management control over the process of contractual incorporation-by-reference, the number of contractually binding documents can proliferate drastically [35].

7.1 Examples of Tiering in Specifications

In an effort to understand the extent of tiering and to determine the types of reference specifications in the different tiers of specifications in the NAVFAC construction guide specifications, the three guide specifications selected for this study were used to illustrate the extent of tiering of reference specifications. Figures 1, 2A and B, and 3 show four tiers of reference specifications for Guide Specifications NFGS-03300, NFGS-03302, and NFGS-03501, respectively. As previously noted, the number of reference specifications in the three guide specifications (Tier One) are 50, 31, and 9, respectively.

One reference specification was selected from each of the three guide specifications to analyze the first four tier levels of reference specifications. In the case of guide specification NFGS-03300, Figure 1 represents only one of the 50 examples for this particular guide specification. Hence, the number of reference specifications contained in the four tiers becomes very large. For example, 49 more figures similar to Figure 1 would be necessary to illustrate all the reference specifications for Guide Specification NFGS-03300. In comparison, 30 more figures similar to Figures 2A and B would be necessary to illustrate the four tiers of reference specifications for Guide Specification NFGS-03302, and 8 more figures similar to Figure 3 would be required to illustrate the four tiers of reference specifications for Guide Specification NFGS-03501. The number of reference specifications in Figure 1 are

50, 8, 53, and 253 for Tiers 1, 2, 3, and 4, respectively. In Figures 2A and B, the corresponding numbers of reference specifications are 31, 18, 127, and 670, and in Figure 3 they are 9, 6, 53, and 351. The number of reference specifications in each tier represent the total number counted and does not take into account that some reference specifications in the four tiers appear several times. Although, the actual number of different reference specifications would be less than the numbers given in Figures 1, 2A and B, and 3. Regardless of this duplication, large numbers of specifications are referenced in the four tiers of specifications for the guide specifications used as examples in this study.

Guide Specification NFGS-03302 was used as an example to estimate the number of reference specifications which would be included though Tier 4. There were 670 reference specifications in Tier 4 for one of the Tier 1 reference specifications. Since there were 31 reference specifications in Tier 1 of this guide specification, the total number of reference specifications through Tier 4 could number in the thousands. As previously stated, there would be duplication and repetition of the reference specifications through the four tiers, however, there would be a vast number of reference specifications for the prime contractor to review and to determine his responsibility for their requirements.

7.2 Types of Reference Specifications in Tiers

In an analysis of the specifications and specification titles pertaining to the four tiers of reference specifications in the three examples, the number of reference specifications of various types in each tier were determined (see Table 2). This table shows that the reference specifications in the guide specifications (first tier) are mostly material or product specifications. Guide Specification NFGS-03300 had 88 percent of the reference specifications (Tier 1) as material or product specifications and as standard methods or practices for materials. For the second through the fourth tiers of the three guide specifications, over 80 percent of the specifications in each tier were related to testing. Furthermore, it appears that over half of the material and product specifications in Tiers 2 through 4 are related to testing and not to construction. This considerably reduces the percentage of material and product specifications in Tiers 2 through 4 given in Table 2. Because of the number of specifications to be reviewed, the intent of whether or not a referenced material specification in a testing specification was applicable to testing or construction was not precisely determined. If a material specification was referenced in a testing specification, it was counted in most cases as a material specification for the purpose of this study. Nevertheless, the number of material and product specifications in Tiers 2 through 4 for all three guide specifications was relatively low.

8. CONCLUSIONS AND RECOMMENDATIONS

The major conclusions and recommendations from this study of guide specifications are presented in the following. They primarily address the NAVFAC Guide Specification system.

a) The NAVFAC Guide Specification system forms an effective basis for the preparation of Navy construction project specifications. It compares favorably with the guide specifications of other Federal agencies and commercially available guide specifications in meeting the needs of Navy construction.

b) Recognizing that the purpose of guide and contract specifications is to convey from the architect/designer to the contractor the purpose, requirements, and details of a project, the reference specification system is necessary to avoid the development of massive guides. Using construction materials as an example, a guide specification which did not reference other specifications would need to describe all the appropriate material tests, including test procedures, requirements for test equipment, the calibration of test equipment, and materials for equipment calibration. The amount of information which would be required in the guide specification would extend, at least, to the fourth tier of the specification tree. Therefore, it is recommended that the reference specification system be continued in NAVFAC guide specifications.

In order to reduce proliferation of reference documents, only the portions needed should be referenced instead of citing the entire document.

c) The most prevalent problem found in the NAVFAC guide specifications was that many of the reference specifications were not the latest revision. It is recommended that NAVFAC explore procedures for frequent updating of guide specifications (at least on a three months schedule) to assure that the latest revisions of the reference specifications are included in the guide specifications.

d) In the Technical Note Section of the three guide specifications reviewed in this study, it was stated that the latest issue of the applicable publications (reference specifications) shall be used after reviewing the proposed document to assure that it will provide a facility meeting minimal essential requirements of the Government. This review may be beyond the ability of the specifications writer since some reference specifications are highly technical and cover many pages. It is recommended that the review of new reference specifications be conducted by a technical expert rather than a specifications writer. If the reference specifications were kept up-to-date, a review by the specifications writer would not be necessary.

e) As mentioned in (c) above, many of the reference specifications in the three selected NAVFAC guide specifications were not current versions. Also, some conflicts were found between the recommendations in the reference specifications and those in the guide specifications. These and other noted deficiencies in the reference specification selection can reduce the quality of a project. The decision rules for reference specification acceptance given in this report should be used to determine the appropriateness of reference specifications.

f) Based on the number of references in, and the analyses of the tiering system in, the three selected NAVFAC guide specifications, it appears feasible and advisable from this limited study to limit a contractor's responsibility for fulfilling the requirements of reference specifications. It is recommended that a contractor be only responsible for the requirements in the first tier of reference specifications. If this recommendation is followed, it will be imperative that all the process and materials requirements appropriate to the actual construction be cited in the guide specifications. However, overspecifying should not be permitted. Proper certification and labeling of materials and products should also be required in the guide specifications to support the prime contractor in order to fulfill this recommendation.

g) NAVFAC specifiers, when preparing construction specifications from guide specifications, search through them to locate the appropriate provisions. Also, they search through reference specifications to choose the appropiate sections to be referenced. Application of computers could facilitate the preparation of construction specifications from guide specifications and reference specifications. For example, the provisions in a guide specification could be placed in knowledge-based format which would facilitate the selection of appropriate parts of guide specifications. It is recommended that the feasibility of using a computerized system for preparing contract specifications from guide specifications be studied.

h) There is an accelerating movement towards electronic storage and transfer of information, and there is increasing foreign competition in construction. Therefore, it is recommended that the implications of computer science and technology for more rapid updating of guide specifications, and for automated development and checking of contract specifications be explored. As an example, this is likely to be important for facilitating the rapid transfer to practice of new technology resulting from research on the repair and rehabilitation of the infrastructure.

9. ACKNOWLEDGEMENTS

This study was sponsored by the Naval Facilities Engineering Command, Design Support Office. The authors appreciate the support and assistance of Thomas R. Rutherford (NAVFAC), Director, Criteria Division, Design Support Office, for providing liaison between NAVFAC and NIST and for his insightful comments, constructive suggestions, and critical review of this report. Sandi Berry (NAVFAC) is also acknowledged for her assistance in providing the authors with DoD documents dealing with specifications. The authors also thank their NIST colleagues, Geoffrey Frohnsdorff and Patrick Cooke, who gave important review comments on this report. The authors appreciate the excellent support of Joan Murphy and Denise Herbert for typing the manuscript.

10. REFERENCES

1. Fischer, Martin A., "Engineering Specifications Writing Guide", Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1983.

2. Simmons, H. Leslie, "The Specifications Writer's Handbook", John Wiley and Sons, Inc., New York, 1985.

3. Fenves, Steven J., Wright, Richard N., Stahl, Fred I., and Reed, Kent A., "Introduction to SASE: Standards Analysis, Synthesis, and Expression", U.S. National Bureau of Standards, NBSIR 87-3513, May 1987.

4. Lewis, Jack R., "Construction Specifications", Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1975.

5. "Manual of Practice", The Construction Specifications Institute, Alexandria, VA, October 1985.

6. "Improving Building Construction Specifications in State and Local Government", Public Technology, Inc., Washington, DC, Sponsor: National Aeronautics and Space Administration, Washington, DC, Report No. NASA-CR-163623, 1980.

7. White, Arthur E., "Specification Deficiencies-Contract Disputes", Proceedings of a Symposium held in conjunction with the ASCE Convention, Conference on Avoiding Contract Disputes held October 21-22, 1985 in Detroit MI, published by ASCE, New York, NY, 1984, pp. 60-69.

8. "Guide Specifications Manual", Design Manual 06.02, Naval Facilities Engineering Command, Alexandria, VA, May 1986.

9. "Summary Report of Questionnaire on Specifications (Ower and Owner Representative Returns)", By the Committee on Specifications of the Construction Division, Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 105, No. CO3, September 1979, pp. 163-186.

10. "Summary Report of Questions on Specifications (Contractor Returns)", By the Task Committee on Specifications of the Construction Division, Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 104, No. CO3, September 1978, pp. 353-359.

11. Jones, Edwin, "Evaluation of Specification Questionnaire Returns", Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. CO2, June 1980, pp. 169-172.

12. Fisk, Edward R., "Evaluation of Owner Comments on Specifications", Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. CO4, December 1980, pp. 469-476.

13. Fisk, Edward R., "Designer Evaluation of Contractor Comments on Specifications", Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 104, No. CO1, March 1978, pp. 77-83.

14. Abdallah, Eli T., "Guidelines for Producing Better Specifications", Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 108, No. CO3, September 1982, pp. 438-444.

15. Goldbloom, Joseph, "Construction Specifications: A One-Book Deal", Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. CO4, December 1980, pp. 601-603.

16. Ibbs, C. Williams, Jr., "Product Specification Practices and Problems", Journal of Construction Engineering and Management Proceedings of the American Society of Civil Engineers, Vol. 111, No. 2, June 1985, pp. 157-172.

17. Wilkinson, Ronald W., "Computerized Specifications on A Small Project", Journal of Construction Engineering and Management, Proceedings of the American Society of Civil Engineers, Vol. 110, No. 3, September 1984, pp. 337-345.

18. Bosserman, Bayard E. and Ford, Maurice E., "Development of Computerized Specifications", Journal of Construction Engineering and Management, Proceedings of the American Society of Civil Engineers, Vol. 110, No.3, September 1984, pp. 375-384.

19. Ibbs, C. Williams, "Brand Name of Equal Product Specifications", Journal of Construction Engineering and Management, Proceedings of the American Society of Civil Engineers, Vol. 112, No. 1, March 1986, pp. 1-13.

20. Myers, Robert W., "Performance Versus Prescriptive Specifications", Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 107, No. CO2, June 1981, pp. 239-245.

21. Moore, William B., Fagan, David, W., Jr., and Cable, John H., "Changing the DoD Construction Guide Specification", (Final Report), Logistics Management Institute, Bethesda, MD, Report No. LMI-ML519, June 1985, 39 pages.

22. "Policies of Federal Agencies On The Use of Certain Special Requirements In Construction Specifications", Federal Construction Council Technical Report No. 87, National Academy Press, Washington, DC, 1987.

23. Hattis, David B., "The Relationship of the Performance Concept to the Planning Process--Developing Performance Requirements for Community Mental Health Centers", National Bureau of Standards Special Publication 361, Vol. 1: Performance Concept in Buildings; Proceedings of the Joint RILEM-ASTM-CIB Symposium, held May 2-5, 1972, Philadelphia, PA, March 1972.

24. "The Federal Construction Guide Specification Program: Organization, Administration, Guidelines, and Procedures", Federal Construction Council Technical Report No. 58-81, National Academy Press, Washington, DC 1981.

25. Harris, Robert J. and Wright, Richard N., "Organization of Building Standards: Systematic Techniques for Scope and Arrangement", U.S. National Bureau of Standards, Building Science Series 136, September 1981.

26. Military Standard 490A, Specification Practices, Department of Defense, Washington DC 20301, Revised June 1985.

27. Blackmon, Robert B., "Assessment of the Need for Standards for Preparing Maintenance and Repair Contracts, Volume 1: Analysis and Recommendations, U.S. Army Corps of Engineers Construction Engineering Research Laboratory Technical Report P-88/01, Vol. 1, October 1987.

28. "Guide Specifications for Small Projects", U.S. Army Engineer Division, Huntsville (CEHND), December 30, 1986.

29. "DoD, Industry, and Nongovernment Standards Bodies Join as Equal Partners", ASTM Standardization News, Vol. 16, No. 2, American Society for Testing and Materials, February 1988, pp. 22-24.

30. Building Code Requirements for Reinforced Concrete (ACI 318-83), American Concrete Institute, 1983.

31. "Matrix Guide Specifications for Facilities Construction Federal and Private", Naval Facilities Engineering Command, Alexandria, VA, March 1988.

32. Rosen, Harold J.", "Principles of Specification Writing", Reinhold Publishing Corporation, New York, 1967.

33. Fenves, Steven J., Rankin, Kirk, and Tejuja, Hotchand K., "The Structure of Building Specifications", U.S. National Bureau of Standards, Building Science series 90, September 1976.

34. Fenves, Steven J. and Wright, Richard N. "The Representation and Use of Design Specifications", U.S. National Bureau of Standards, Technical Note 940, June 1977.

35. Defense Standardization Manual DoD 4120.3-M, Defense Standardization and Specification Program Policies, Procedures and Instructions, Office of the Under Secretary of Defense for Research and Engineering, Washington, DC 20301, Revised April 1987.

Figure 1. Tiers of Reference Specifications in Guide Specification NFGS-03300, Cast-In-Place-Concrete.

Guide Specification	NFGS-03300 (March 1985) Amendment-1, January 1988							
Tier One 50 applicable publications[2] 64% material specs. 24% standard practices 12% test methods	ASTM C39-83b[1]							
Tier Two 8 applicable publications 100% Testing	ASTM C31	ASTM C42	ASTM C192	ASTM C617	ASTM C873	ASTM E4	ASTM E74	ASTM Manual (MA&CT)
Tier Three 53 applicable publications 89% testing 11% material specs.	ASTM C143 ASTM C172 ASTM C173 ASTM C192 ASTM C231 ASTM C470 ASTM C511 ASTM C617	ASTM C39 ASTM C78 ASTM C116 ASTM C174 ASTM C192 ASTM C496 ASTM C617	ASTM C31 ASTM C33 ASTM C70 ASTM C125 ASTM C127 ASTM C128 ASTM C138 ASTM C143 ASTM C172 ASTM C173 ASTM C231 ASTM C330 ASTM C470 ASTM C511 ASTM C566 ASTM C567 ASTM C617 ASTM D448 NBS HB 44	ASTM C109 ASTM C150 ASTM C287 ASTM C472 ANSI B 46.1	ASTM C39 ASTM C42 ASTM C470 ASTM C617 ASTM C683	ASTM D76 ASTM E74 ASTM E467	ASTM E4 ASTM E29 ANSI B 46.1 NBS HB 44 NBS HB 105-1 NBS TN 577	None
Tier Four 253 applicable publications 82% testing 12% material specs. 5% definitions	37[3]	35	106	28	23	21	3	0

[1]This figure represents only one of the 50 Tier One reference specifications. ASTM C39 is the Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

[2]Applicable publications are considered as reference specifications.

[3]Number of reference specifications in Tier Four.

Figure 2A. Tiers of Reference Specifications in Guide Specification NFGS-03302, Cast-In-Place-Concrete. (Minor Construction)

Guide Specification	NFGS-03302 (October 1986)								
Tier One 31 applicable publications[2] 84% material specs. 13% standard practices 3% test methods	ASTM C150-85[1]								
Tier Two 18 applicable publications 78% Testing, 5% definitions 17% material specs.	ASTM C33	ASTM C109	ASTM C114	ASTM C115	ASTM C151	ASTM C183	ASTM C185	ASTM C186	ASTM C191
Tier Three 127 applicable publications 86% testing, 1% definitions 12% material specs 1% standard practices.	ASTM C29 ASTM C40 ASTM C87 ASTM C88 ASTM C117 ASTM C123 ASTM C125 ASTM C131 ASTM C136 ASTM C142 ASTM C227 ASTM C289 ASTM C294 ASTM C295 ASTM C342 ASTM C535 ASTM C586 ASTM C666 ASTM D75 ASTM D3665 ASTM E11 STP 169B	ASTM C230 ASTM C305 ASTM C349 ASTM C670 ASTM C778	ASTM C115 ASTM C150 ASTM C183 ASTM C595 ASTM D1193 ASTM E29 ASTM E275 ASTM E617 ASTM E832	ASTM C430 ASTM C670	ASTM C187 ASTM C305 ASTM C490 ASTM C511 ASTM E177	None	ASTM C183 ASTM C230 ASTM C305 ASTM C511 ASTM C778 ASTM C1005	ASTM C114 ASTM E11	ASTM C305 ASTM C490 ASTM C670
Tier Four 670 applicable publications 87% testing, 3% definitions 9% material specs. 1% marking	127[3]	7	58	4	6	None	9	16	4

Note: Figures 2A and 2B present tiers of reference specifications for Guide Specification NFGS-03302

[1]This figure represents only one of the 31 Tier One reference specifications. ASTM C150 is the Standard Specification for Portland Cement.

[2]Applicable publications are considered as reference specifications.

[3]Number of reference specifications in Tier Four.

Figure 2B. Tiers of Reference Specifications in Guide Specification NFGS-03302, Cast-In-Place-Concrete. (Minor Construction)

Guide Specification	NFGS-03302 (October 1986)								
Tier One 31 applicable publications[2] 84% material specs. 13% standard practices 3% test methods	ASTM C150-85[1]								
Tier Two 18 applicable publications 78% Testing, 5% definitions 17% material specs.	ASTM C204	ASTM C219	ASTM C226	ASTM C265	ASTM C266	ASTM C451	ASTM C452	ASTM C465	ASTM C563
Tier Three 127 applicable publications 86% testing, 1% definitions 1% standard practices	ASTM C670 UU-P-236 NBS 114	None	ASTM C33 ASTM C39 ASTM C109 ASTM C114 ASTM C115 ASTM C138 ASTM C143 ASTM C150 ASTM C151 ASTM C175 ASTM C185 ASTM C187 ASTM C191 ASTM C192 ASTM C204 ASTM C231 ASTM C293 ASTM C666 ACI 211.1	ASTM C109 ASTM C114 ASTM C150 ASTM C305 ASTM E11	ASTM C187 ASTM C191 ASTM C305 ASTM C490	ASTM C150 ASTM C183 ASTM C187 ASTM C305 ASTM C490 ASTM C670 ASTM C1193	ASTM C109 ASTM C150 ASTM C230 ASTM C305 ASTM C471 ASTM C490 ASTM C511 ASTM C778 ASTM C1005	ASTM C33 ASTM C39 ASTM C78 ASTM C109 ASTM C114 ASTM C115 ASTM C138 ASTM C143 ASTM C150 ASTM C151 ASTM C173 ASTM C185 ASTM C187 ASTM C191 ASTM C192 ASTM C204 ASTM C226 ASTM C231 ASTM C293 ASTM C595 ASTM C596 ASTM C617	ASTM C109 ASTM C185 ASTM C305 ASTM C471
Tier Four 670 aqpplicable publications 87% testing, 3% definitions 9% material specs. 1% marking	2[3]	0	128	39	9	32	37	178	14

Note: Figures 2A and 2B present tiers of reference specifications for Guide Specification NFGS-03302

[1]This figure represents only one of the 31 Tier One reference specifications. ASTM C150 is the Standard Specification for Portland Cement.

[2]Applicable publications are considered as reference specifications.

[3]Number of reference specifications in Tier Four.

Figure 3. Tiers of Reference Specifications in Guide Specification NFGS-03501, Insulating Concrete Roof Deck System.

Guide Specification	NFGS-03501 (April 1987)					
Tier One 9 applicable publications[2] 56% material specs 33% testing 11% reference	ASTM C796-80 (R86)[1]					
Tier Two 6 applicable publications 83% testing 17% material Specs	ASTM C88	ASTM C150	ASTM C192	ASTM C495	ASTM C496	ASTM C511
Tier Three 53 applicable publications 91% testing, 2% definitions 7% material specs	ASTM C33 ASTM C670 ASTM C702 ASTM D75 ASTM D3665 ASTM E11 ASTM E100 ASTM E323	ASTM C33 ASTM C109 ASTM C114 ASTM C115 ASTM C151 ASTM C183 ASTM C185 ASTM C186 ASTM C191 ASTM C204 ASTM C226 ASTM C265 ASTM C266 ASTM C451 ASTM C452 ASTM C465 ASTM C563	ASTM C31 ASTM C33 ASTM C70 ASTM C125 ASTM C127 ASTM C128 ASTM C138 ASTM C143 ASTM C172 ASTM C173 ASTM C231 ASTM C330 ASTM C470 ASTM C511 ASTM C566 ASTM C567 ASTM C617 ASTM D448	ASTM C39 ASTM C88 ASTM C109 ASTM C172 ASTM C617 ASTM C670	ASTM C31 ASTM C39 ASTM C42 ASTM C192	None
Tier Four 351 applicable publications 83% testing, 5% definitions 11% material specs 1%marking	51[3]	139	113	30	18	0

[1]This figure represents only one of the 9 Tier One reference specifications. ASTM C796 is the Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam.

[2]Applicable publications are considered as reference specifications.

Table 1. Types and Styles of Construction Project Specifications as Described by Lewis [4].

TYPE	PRINCIPAL FEATURES	ADVANTAGE/ DISADVANTAGE	WHERE USED
Closed	Limits material to one or few.	Limits competition. Allows architect to hold quality.	Manufacturer's specifications. Remodel work or where matching is required.
Open	Allows any material that meets requirements.	Allows competition. May include low quality items that barely meet requirements.	Government-financed projects. Commercial projects.
Manufacturer's	Information for writer. Usually closed type.	Source for information. Usually requires rewrite to eliminate closed aspects.	Information. May be copied in some uses.
Federal	Open type.	Requirements printed. May include many items not used. Used as master copy material.	As reference in other types. United States government work.
Performance	Specifies end result.	Allows contractor to select material and/or method. Limits architect's control to accept or reject.	Commercial or experimental projects. Not on government projects.
Streamlined	Eliminates extra words. Open or closed type.	Reduces volume of paper. May mislead intent if wrong words eliminated.	Now becoming obsolete.
Tabulation	No sentences. Only requires notations in spaces.	Short. No methods described. Limits control of material.	Some governmental or speculative housing or lending agencies.

Table 2. Examples of Types of Reference Specifications in Tiers

Guide Spec	Tier No.	Applicable Publications[a]	Percent of Type of Specification					
			Material or Product Spec.	Std. Method or Practice	Related to Testing	Definitions	Reference	Marking
NFGS-03300	1st	50	64	24	12	—	—	—
	2nd	8	—	—	100	—	—	—
	3rd	55	12	—	88	—	—	—
	4th	247	12	1	81	6	—	—
NFGS-03302	1st	31	84	3	13	—	—	—
	2nd	18	17	—	78	5	—	—
	3rd	127	12	1	86	1	—	—
	4TH	662	9	—	87	3	—	1
NFGS-03501	1st	9	56	—	33	—	11	—
	2nd	6	17	—	83	—	—	—
	3rd	53	7	—	91	2	—	—
	4th	351	11	—	83	5	—	1

[a]One specification selected from Tier 1. Tier 2 contains specifications referenced in the selected specification from Tier 1. Tiers 3 and 4, based on all the reference specifications from the previous tier.

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NISTIR 89-4094	2. Performing Organ. Report No.	3. Publication Date JUNE 1989

4. TITLE AND SUBTITLE

Guide Specifications and Reference Specification System

5. AUTHOR(S)
Robert G. Mathey, James R. Clifton

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
U.S. DEPARTMENT OF COMMERCE
GAITHERSBURG, MD 20899

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)
Naval Facilities Engineering Command
Design Support Office
Alexandria, VA 22332-2300

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

Guide specifications enable faster, more efficient, and cost-effective preparation of construction project specifications. By editing guide specifications instead of writing new requirements for each project, the produced construction project specifications are also generally of higher and more consistent quality, and should lead to less disputes and litigation. Established national specifications are referenced in guide specifications and this technique has proven extremely effective in communicating material, product, system, and construction requirements. Reference specifications are also used for workmanship standards.

This report is based on a study aimed at evaluating the need for and the effectiveness of Navy guide specifications and the selection and need for reference specifications in guide specifications. Decision rules were developed to assist in the selection of the most appropriate reference specifications. Tiering of referenced documents in guide specifications was assessed with regard to the volume of reference material that the contractor and contract administrator must study and act upon to comply with the terms of the contract. Recommendations on ways to improve Navy guide specifications and to resolve issues dealing with selection of reference documents and with their tiering are presented.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)
construction; construction project specifications; federal construction; guide specifications; NAVFAC; reference specifications; specifications; specification tiering; standards; tiering

13. AVAILABILITY

☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES
78

15. Price
$14.95

USCOMM-DC 6043-P80