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INTRODUCTION

Construction documents prepared by architects and their consultants consist primarily of drawings and specifications. Architects must understand the purpose of these documents and the conventions used in organizing and producing them.

Drawings and specifications convey the owner's and architect's design intentions to the contractors responsible for bidding and constructing the project. In order to obtain competitive bids from contractors and to enable construction to proceed with a minimum number of changes and conflicts, the construction documents must be complete, concise, correct, clear, and coordinated. If, because of negligence by the architect and/or the architect's consultants in preparing the construction documents, the construction budget is exceeded, or an inordinate number of change orders are required during construction, the architect may be subjected to professional liability claims.

The building industry has developed standards for construction documents to achieve these objectives. Architects who have a clear understanding of these standards will be prepared to communicate with consultants and contractors and to objectively review and evaluate their work.

CONSTRUCTION DOCUMENTS

Correlation Between Drawings and Specifications

Drawings and specifications must be consistent with each other to avoid misinterpretation. Drawings define physical relationships between materials, products, and systems. They indicate physical dimensions and locations of construction elements. Sizes, quantities (implicitly), and configurations are all shown on drawings. Specifications complement the drawings. They express in writing the requirements regarding quality, methods and techniques of installation, and desired performance. For an example of the coordination of drawings and specifications, see page 2-4.

Construction Drawings

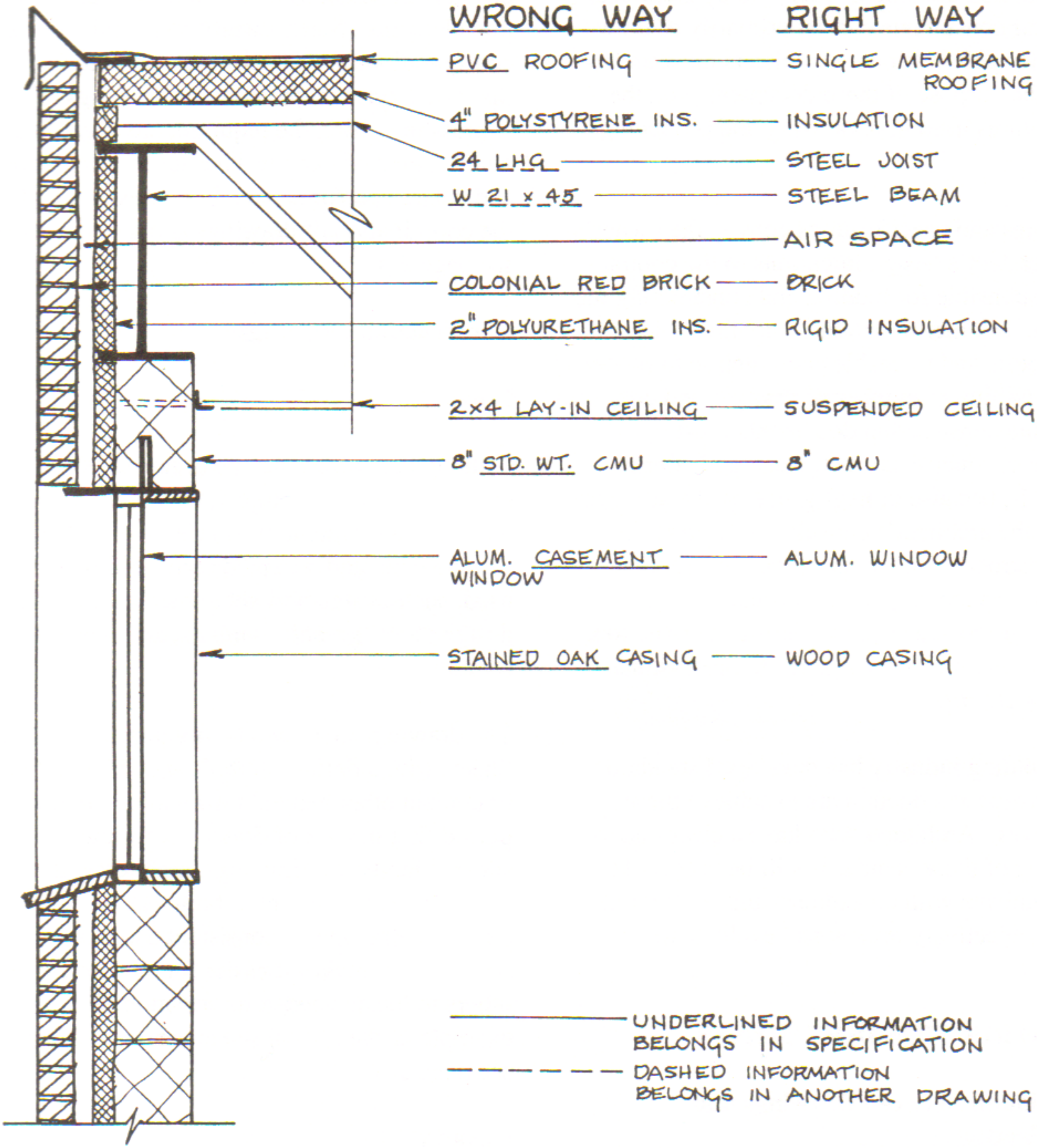
Logic

Although drawings may be organized somewhat differently for each project, they usually communicate their intent most effectively when recognizable and accepted conventions are used, such as standard abbreviations, material designations, graphic symbols, and schedule formats.

The drawings must also be organized logically. Sheets which define symbols and abbreviations or contain other general information are usually placed first in a set of drawings, followed by site and landscape drawings, architectural drawings, structural, plumbing, HVAC, and electrical drawings. Consistent use of this arrangement makes it easier for contractors and others to locate needed information. For an example of the typical sequence of drawings, see page 2-5.

Clarity

Since the purpose of drawings is to convey information to contractors and others, architects



COORDINATION OF DRAWINGS & SPECIFICATIONS

TYPICAL SEQUENCE OF DRAWINGS

Title Sheet, including list of drawings, list of abbreviations, material and symbol schedules, and general notes

Architectural Drawings
- *Code compliance diagrams*
- *Site plan, including vicinity map*
- *Site details*
- *Landscape plan(s) and details (if required)*
- *Demolition plans (if required)*
- *Floor plan(s)*
- *Exterior elevations*
- *Building sections*
- *Wall sections*
- *Stair and elevator plans, sections, and details*
- *Supplementary plan(s) and details of special facilities (if required)*
- *Exterior details*
- *Window types*
- *Window details*
- *Interior elevations*
- *Interior details*
- *Millwork details*
- *Finish schedules*
- *Door and frame schedule and details*
- *Reflected ceiling plan(s)*
- *Roof plan(s)*
- *Miscellaneous details*

Structural Drawings
- *Foundation plan(s)*
- *Floor framing plan(s)*
- *Roof framing plan(s)*
- *Structural sections*
- *Structural details*
- *Schedules, including footings, beams, joists, and columns*

Plumbing Drawings
- *Site plan*
- *Plumbing plans*
- *Fire protection plans (if required)*
- *Plumbing details*
- *Plumbing schedules, including plumbing fixtures*
- *Riser diagrams*

Heating, Ventilating, and Air Conditioning (HVAC) Drawings
- *HVAC plan(s)*
- *HVAC details*
- *HVAC schedules*
- *Riser diagrams*

Electrical drawings
- *Site plan*
- *Electrical plan(s), including power and lighting*
- *Single line diagrams*
- *Electrical details*
- *Electrical schedules, including lighting fixtures*

must present the information clearly, accurately, and at appropriate scales. If drawings are not sufficiently clear or complete, they will generate questions or unintended results. If they are inadequately dimensioned, inaccurate, or are drawn at inappropriate scales, they are likely to cause errors in the field, and possibly additional costs or delays.

Clarity is a result of common sense and coordination. Redundancy, ambiguities, and omissions must be avoided. Each item should be explained and drawn with adequate detail and placed in the most logical location in a set of drawings. Graphic symbols, designations, and cross-references are often necessary. Using cross-references reduces the amount of drawing that must be done, and subsequent revisions only need to be made once.

It is essential that the construction documents clearly delineate the scope of work required for the project. Generally anything shown on the drawings is part of the scope of work. However, there are several important exceptions to this general statement. For example, on site drawings, the surroundings are usually shown. To delineate the scope of work required by the contract, a limit line must be drawn. For utilities, a point of connection must be shown. For renovations or additions, the existing conditions are usually shown. The drawings must indicate by graphic and written notation the existing construction to remain, the existing construction to be removed, and the new construction. Equipment or other items furnished by the owner may be shown on the drawings to establish dimensional criteria. These should be noted as not-in-contract (NIC).

Relation to Shop Drawings, Product Data, and Samples

No set of construction drawings is ever truly complete. The purpose of drawings is to convey intended results, and contractors can achieve these results by choosing from among various specified or approved products.

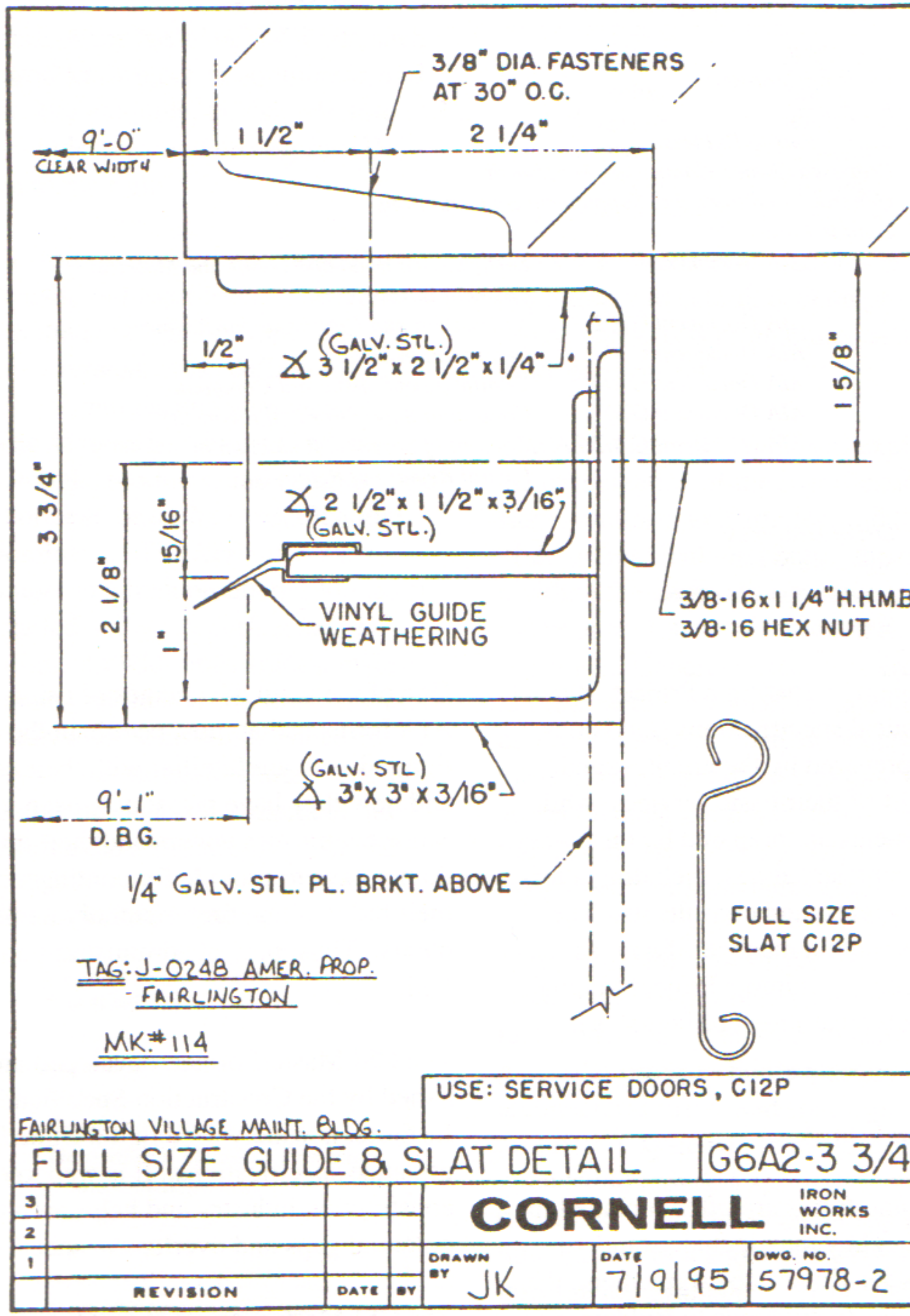
Since several products may satisfy the intent of the specifications, but may vary in size or require different installation methods and details, contractors prepare shop drawings to graphically indicate the fabrication and installation of a particular product. See page 2-7.

Product data and samples are similar in purpose to shop drawings. Product data provide specific information about a product's performance in the form of charts, brochures, diagrams, or instructions. Samples are representative of a material's color, texture, finish, workmanship, etc., and establish physical standards for future work. Architects review all such submittals—shop drawings, product data, and samples—but only to determine whether or not they comply with the design intent. See *Construction Documents and Services 2*, Lesson Two, for a detailed description of submittals.

Construction Specifications

Project Manual

A Project Manual contains technical information, as well as other documents related to legal and procedural requirements. These include bidding documents, applicable contract forms, documents which relate to equal employment opportunity and labor wage requirements, and so on.



TYPICAL SHOP DRAWING

TYPICAL PROJECT MANUAL CONTENTS

Title Sheet
Table of Contents
Bid Form
Instructions to Bidders
Proposed Owner-Contractor Agreement
General Conditions and Supplementary Conditions
Sample Forms

AIA Document A311	*Performance Bond and Labor and Material Payment Bond*
AIA Document G702	*Application and Certificate for Payment*
AIA Document G703	*Continuation Sheet*
AIA Document G704	*Certificate of Substantial Completion*
AIA Document G707	*Consent of Surety to Final Payment*
AIA Document G707A	*Consent of Surety to Reduction in or Partial Release of Retainage*

List of Drawings
Signature Sheet
Index to Specifications
Specification Divisions 1 through 16

An architect's role in preparing a Project Manual is limited. Technical specifications (Divisions 1 through 16) are prepared by the architect and consultants as part of their basic services, while most other documents are prepared by the owner and the owner's representatives, including attorneys, insurances agents, and consultants. The architect, or construction manager if any, assembles these documents into a Project Manual. For contents of a typical Project Manual, see above.

Use of Standard Forms

AIA documents and forms are often included in Project Manuals. They may include standard forms for the Owner-Contractor Agreement, the General Conditions, Instructions to Bidders, various bond forms, as well as administrative forms relating to payments to the contractor, field administration, and completion of construction.

One of the main advantages of using standard AIA forms is that most people in the construction industry are familiar with their contents and how they have previously been interpreted. Since contractors understand their intent, they do not have to provide for contingencies in their bid to allow for potentially unclear documents. Thus, project administration is simplified.

The CSI MasterFormat, developed and published by the Construction Specifications Institute, is widely used in the United States to organize specifications. It is well known in the construction industry and helps architects avoid potential gaps and overlaps in specifications.

The CSI MasterFormat is divided into *Divisions, Sections,* and *Parts*. There are 16 CSI *Divisions* which comprise the permanent framework of the specifications. Each Division has a fixed name and number, as shown below. A *Section* describes the basic unit of work, such as a specific product or piece of equipment, and its installation. For example, Division 9, Finishes, might include a Section on Gypsum Drywall, as shown to the right.

Each Section is further divided into three *Parts*: General, Materials, and Execution. The *General Part* deals with the coverage or scope of a Section. It describes related work, definitions, quality control, submittals, and guarantees/ warranties. The *Materials Part* lists and describes the materials, products, and equipment to be used. In shortened or *outline* specifications, this Part predominates. The *Execution Part* details the manner in which products and materials will be installed and work performed. In addition, coordination with other trades, inspection and acceptance of their work, tests, and other similar items may also be covered. Since contractors usually are permitted to choose among various acceptable products or equipment, it is best not to describe the attributes of particular items too specifically. Affording contractors the opportunity to submit data on products and preferred methods is more practical and, possibly, more economical.

CSI MASTERFORMAT

Division	*1*	*General Requirements*
Division	*2*	*Site Work*
Division	*3*	*Concrete*
Division	*4*	*Masonry*
Division	*5*	*Metals*
Division	*6*	*Wood and Plastics*
Division	*7*	*Thermal and Moisture Protection*
Division	*8*	*Doors and Windows*
Division	*9*	*Finishes*
Division	*10*	*Specialties*
Division	*11*	*Equipment*
Division	*12*	*Furnishings*
Division	*13*	*Special Construction*
Division	*14*	*Conveying Systems*
Division	*15*	*Mechanical*
Division	*16*	*Electrical*

TYPICAL SECTION HEADINGS

09250	*Gypsum Drywall*
09300	*Tile*
09550	*Wood Flooring*
09680	*Carpeting*
09900	*Painting*

The AIA General Conditions explicitly states that the organization of the specifications into divisions, sections, and articles, and the arrangement of drawings shall *not* control the contractor in dividing the work among subcontractors or in establishing the extent of work to be performed by any trade. General contractors are generally more familiar with labor markets and union labor jurisdiction agreements than architects. Each contractor is also free to utilize a unique procedure for accomplishing the required work and must be responsible for covering potential gaps in the assignments of subcontractors.

Master specifications have been developed using word processing programs which provide automated methods of editing specifications to suit a particular project. Some masters are developed by architectural firms, and some are commercial or proprietary systems. In either case, masters are intended to reduce a specifier's clerical and repetitive work. They allow architects to spend more time on research and make written technical information available to project teams in the early stages of the design process.

Before master specifications were developed, specifiers usually edited sections from previous projects or created new sections based on data from manufacturers and trade associations. The first master specifications were *text-based*, comprising comprehensive data bases of practically all available products and methods. A recent concept is *knowledge-based* specifications, which use a dialog (question-and-answer) method to access the data bases. Text-based systems are reductive, while knowledge-based systems are additive.

However, there are some problems associated with the use of master systems. Since it is easier to edit by deleting unnecessary or inapplicable material than to write new material, a master specification should be applicable to every project. Unfortunately, it is difficult to create a master which is totally comprehensive.

It is also difficult to maintain an accurate and up-to-date master system with rapidly changing technology. For these reasons, many architects subscribe to one of the commercially available proprietary systems. Whichever system is used, it is important to guard against accepting materials and processes merely because they are listed in the master, instead of thorough, independent analysis.

Organization

The relationship between the AIA General Conditions and Division One-General Requirements of the CSI Specifications must be understood. The General Conditions contains contractual provisions that elaborate on elements of the AIA Owner-Contractor Agreement. They are intended to apply to many projects and situations. By contrast, the material in Division One of the specifications describes the administrative rules and work-related provisions for the specific project. A well-written Division One can help a project run smoothly during the construction phase. An example of the typical sections in Division One is shown below.

DIVISION ONE, GENERAL REQUIREMENTS

CSI Sections

01010	*Summary of Work*
01025	*Payment, Modification, and Completion Procedures*
01031	*Alternates*
01033	*Allowances*
01034	*Unit Prices*
01200	*Progress Documentation and Procedures*
01300	*Submittals*
01400	*Quality Control Procedures*
01500	*Temporary Facilities and Services*
01600	*Product Requirements and Substitutions*
01700	*Construction Procedures*
01800	*Project Record Documents*

Types of Technical Specifications

There are several types of technical specifications, and examples of each may be found in any Project Manual. There is nothing inherently wrong with mixing types if they are used correctly.

Proprietary specifications call for desired materials, products, systems, and equipment by their trade names and model numbers. Proprietary specifications are relatively easy to prepare since they rely on commercially available products, which are described in detail in their manufacturers' literature, not in the specifications. Architects should thoroughly investigate a manufacturer's claims for such products and systems. The track record of the manufacturer and the product, as well as its suitability for a particular application, should be carefully investigated.

There are two kinds of proprietary specifications: *closed* (sole source) and *open* (equal). Closed specifications require a particular brand or trade name and do not permit substitution. They are intended for situations where only one product will provide the desired result. For example, in a renovation project where only a few windows need to be replaced, a specific brand and model of window may be required. Closed specifications are not usually permitted on publicly-funded projects, where open, competitive bidding is required.

Open specifications name several (usually three) acceptable materials, products, or systems, and contractors may use any one of them. Alternatively, other approved products which match the capabilities and quality of the named items may be used if the open proprietary specification contains an *approved equal* clause. Open specifications are most often used on publicly-funded projects because they promote competition while avoiding questions of impropriety or favoritism in the selection of materials, products, and systems. Open specifications are also used on private projects because they allow contractors to apply their expertise to the construction process while decreasing costs through open competition.

Frequently, the architect may have to determine whether a material or product proposed to be substituted by the contractor is equal in quality and performance to that specified. Division One, General Requirements, must be specific in describing the administrative procedures for contractors to follow in order to obtain approval for such substitutions. The contractor should be responsible for submitting complete technical data to the architect for evaluation. Without the architect's review and approval, a substitution cannot be considered to be an *approved equal*.

In evaluating proposed substitutions, architects must determine whether the aesthetic intent will be met. Furthermore, they must consider value, quality, warranties, the manufacturer's reputation, compliance with code requirements and regulations, operating and maintenance costs, size and weight, ease of construction, construction labor and equipment requirements, and operational characteristics.

TYPICAL EXAMPLE OF PROPRIETARY OPEN SPECIFICATION

A. Admixtures

1. Water-reducing and air-entraining agents shall be used in all concrete, in strict accordance with the manufacturer's printed instructions. Total air entrained in freshly mixed concrete shall be 5.0% plus or minus 1.0% of volume of concrete with required strengths maintained.

2. Water-Reducing Agent: "Sonotard WR" by Sonneborn Building Products, "WRDA" by W. R. Grace Company, "Pozzolith 100" by Master Builders Company, or Sika "Plastocrete N." Water-reducing agent shall be by same manufacturer as air-entraining agent.

3. Air-Entraining Agent: "Darex" by W. R. Grace Company, "Aerolith" by Sonneborn Building Products, "MBVR" by Master Builders Company, or Sika "AER."

TYPICAL EXAMPLE OF PERFORMANCE SPECIFICATION

A. *Sprayed-On Fireproofing*

Materials, procedures for application, dry densities, and thicknesses necessary to provide the required protection shall have been tested in accordance with ASTM E-119 and approved by UL for the uses indicated.

B. *Structural Steel Members and Roof Deck*

All structural steel members and roof deck shall be protected under this Section with adequate fireproofing thicknesses and densities to provide the following fire resistance ratings.

Steel columns and beams supporting more than one (1) floor .... 3 hours
Steel columns supporting roof deck .... 2 hours
Metal roof deck and supporting steel members .... 1 hour
Steel members supporting one (1) floor .... 2 hours

Load: In addition, beams shall have sustained the applied load during the ASTM E-119 fire endurance test; and the transmission of heat through the beam protection during the period of fire exposure for the specified rating shall not have raised the average (arithmetical) temperature of the steel at any one of four sections above 1200 degrees F (648.8 degrees C) and shall not have raised the temperature above 1400 degrees F (760.0 degrees C) at any one of the measured points.

Thickness and Density: Where the thickness of fire protection material for the specified fire resistance rating is given as an average thickness, the minimum thickness shall be that given as average thickness. Acceptable minimum thickness of applied material shall be that measured at specified dry density. Minimum applied dry density per cubic foot shall be 18 pounds.

Fire ratings interpolated or extrapolated from actual test data will not be accepted. Provide evidence prior to application that proposed materials and installation methods and materials have been approved by all authorities having jurisdiction.

Substitute products or systems do not have to be identical to those specified, since not all the features of a specified product may be required. If a product can meet desired results and has the most important features, substitutions may be acceptable.

Performance specifications define products or systems by describing desired end results which are performance oriented. In such specifications, the precise composition of individual components or systems is not described. This method allows contractors and manufacturers to apply their unique expertise and encourages broad competition and maximum creative input. Performance specifications are most appropriate when new or unusual products or systems are required or when innovation is necessary.

It can be challenging to prepare performance specifications. Describing the problems or the conditions in which products or systems must operate, and the parameters for acceptable solutions, is difficult. Performance specifications must explicitly define required testing methods and procedures for evaluating performance.

TYPICAL EXAMPLE OF REFERENCE SPECIFICATION

A. *Steel Stud Shear Connectors shall conform to the requirements of Articles 4.26 and 4.27 of "Structural Welding Code" AWS D1.1-77 of the American Welding Society.*

B. *Bolts, Nuts and Washers shall comply with ASTM A325. Bolt dimensions shall comply with requirements of ANSI Standard B18.2 for structural bolts, except that the radii of the filler under the bolt head shall not be less than 1/32" for bolts up to 1" in diameter. Nut dimensions shall comply with requirements of ANSI B18.2 for heavy semi-finished hexagonal nuts. Circular washers shall be flat and smooth and bevel washers square or rectangular. All washers shall comply with requirements of ANSI B27.2 for Type A washers. Where clipping of washers is necessary, clip one side only and not closer than 7/8 of the bolt diameter from the center of the washer.*

TYPICAL EXAMPLE OF DESCRIPTIVE SPECIFICATION

Solid Wood Door Construction

A. *Except as otherwise indicated, all flush wood doors (except UL doors specified hereinafter) shall be wood solid core doors 3'-0" x 7'-0", 1-3/4" thick of 5-ply construction with face veneers bonded to both faces. Cores shall be solid stave low density wood blocks bonded together under heat and pressure. Cross bands shall be thoroughly kiln-dried hard-wood, 1/10" thick, extending full width of door. Core construction shall be AWI Type "SLC," non-resinous wood.*

B. *Face veneers shall be standard thickness (1/28") paint grade veneer. Vertical stile edges and top and bottom rail edges shall be hardwood. Vertical edges shall be 5/8" minimum, top and bottom 2 rails shall be 1-1/4" minimum. Face veneers shall be AWI Type "1." Doors shall be completely sanded, ready to receive paint finish in the field under PAINTING Section.*

C. *Solid core doors shall meet or exceed the requirements of U. S. Department of Commerce Commercial Standard CS-171, and shall be equal to DSC-1 manufactured by Weyerhaeuser Company, or equal as approved by the Architect from manufacturer specified hereinbefore. Except as otherwise indicated, doors shall be AWI "Custom" Grade.*

Energy consumption costs, aesthetics, and similar factors may be especially difficult to specify.

Reference specifications refer to quality standards established by recognized testing authorities or by the federal government. They are typically used in conjunction with other types of specifications. It should be understood, however, that the quality and performance described in the referenced specifications may only be a minimum level and not appropriate or sufficient for the specific application. An architect's specifications must clearly state which parts of the referenced specifications are meant to apply. Standard reference specifications are also dated, and the latest version should be researched before it is cited.

Descriptive specifications are the most detailed of all specifications. They describe all components of products, their arrangement and methods of assembly, physical and chemical properties, arrangement and relationship of parts, and numerous other details and requirements. In descriptive specifications, the architect assumes total responsibility for the function and performance of a product. Unless he or she is certain

TYPICAL EXAMPLE OF CASH ALLOWANCE SPECIFICATION

A "Schedule of Allowances," showing amounts included in Contract Sum, is included at the end of this Section. Coordinate allowance Work with related Work, to ensure that each selection is completely integrated and interfaced with related Work. Requirements for the Work of allowances are shown and specified, to extent established by date of Contract Documents; additional requirements are established by Change Order. At earliest possible date, advise Architect of date each final allowance selection must be completed. Submit proposals for allowance Work as directed, and in the manner specified for Change Orders. Indicate quantities, unit costs, total purchase amounts, taxes, delivery charges and trade discounts. Where requested, furnish detailed breakdown of quantity survey. Contractor mark-up on overrun of allowance purchases will be permitted where purchase amount exceeds established allowance by more than 15%; otherwise, and except as otherwise indicated, amount of Change Order on each allowance will be difference between purchase amount and allowance. Deliver excess materials of allowance Work to Owner's storage space, or dispose of by other means as directed.

SCHEDULE OF ALLOWANCES

Allowance No. 1	*A lump sum of $3,000 for purchase of finish hardware, as defined by and specified in Specification sections of Division 8.*
Allowance No. 2	*A lump sum of $5,000 for purchase of carpet, as defined by and specified in Specification sections of Division 9.*

the assembled product will function properly, the use of this type of specification should be avoided. See page 2-13.

Cash allowance specifications are used in lieu of specifying a particular portion of the work. Under this method, an architect directs bidders to set aside a specified amount of money to be applied to the construction work at the architect's direction. Cash allowance specifications are used when full information on levels of quality has not been determined or is not available at the time bids are solicited. Hardware and carpeting are often handled in this manner. Types and quantities of hardware may be determined on the basis of the drawings, while levels of quality may have to be determined later. Similarly, the extent of carpeting may be known, but not the type or quality. These determinations are sometimes delayed in order to meet a project's budget limitations.

Cash allowances may be used for the purchase and delivery of the product only, in which case the installation is indicated in the construction documents and included in the base bid. Alternatively, a cash allowance may be used for both furnishing and installing the product.

In some cases, products are indicated as *owner furnished-contractor installed* on the construction documents. Although not a cash allowance, an owner-furnished product may be installed as part of the contractor's scope of work. A product indicated as *NIC (not-in-contract)* is neither furnished nor installed by the contractor.

If cash allowances are used, specifications should include information on installation methods, the dollar amount of the allowance, and methods of measuring costs to be applied against allowance amounts. When installations are complete, costs can be compared with allowance amounts and the difference credited to the owner or contractor as appropriate. The example on page 2-14 is taken from Division One, General Requirements. The installation requirements are located in Divisions 8 and 9 as noted.

Effect of Multiple Prime Contracts

When multiple prime contracts are used, rather than one general contract, specification sections may have to be written for individual construction trades. This situation, which often occurs on public projects, requires increased effort on the part of the architect. First, architects must understand local trade union work rules and jurisdictional requirements. Second, many parts of the specifications must be duplicated, increasing the coordination required of architects. For example, each section must include its own agreement, general conditions, and general requirements documents. If there are gaps in assignment of construction work, the architect may be held responsible for such omissions.

Interpretation

Where construction documents are inconsistent or ambiguous, or have gaps or overlaps in coverage, they may be open to interpretation.

When two clauses in the specifications conflict, the more specific clause will usually prevail over the more general clause. Handwritten provisions will usually prevail over typewritten provisions, which in turn take precedence over pre-printed provisions. These cases illustrate the principle that individual and personal attention to an item more likely reflects the author's intent.

When two drawings conflict or are inconsistent, the more recent drawing will usually prevail. Dates of all revisions should appear on drawings, and the items involved in each revision should be clearly indicated. When different drawings are prepared at the same time, large scale detailed drawings will usually prevail over small scale general drawings, such as floor plans and elevations. This type of hierarchy can be made part of the construction contract by incorporation in the Supplementary Conditions.

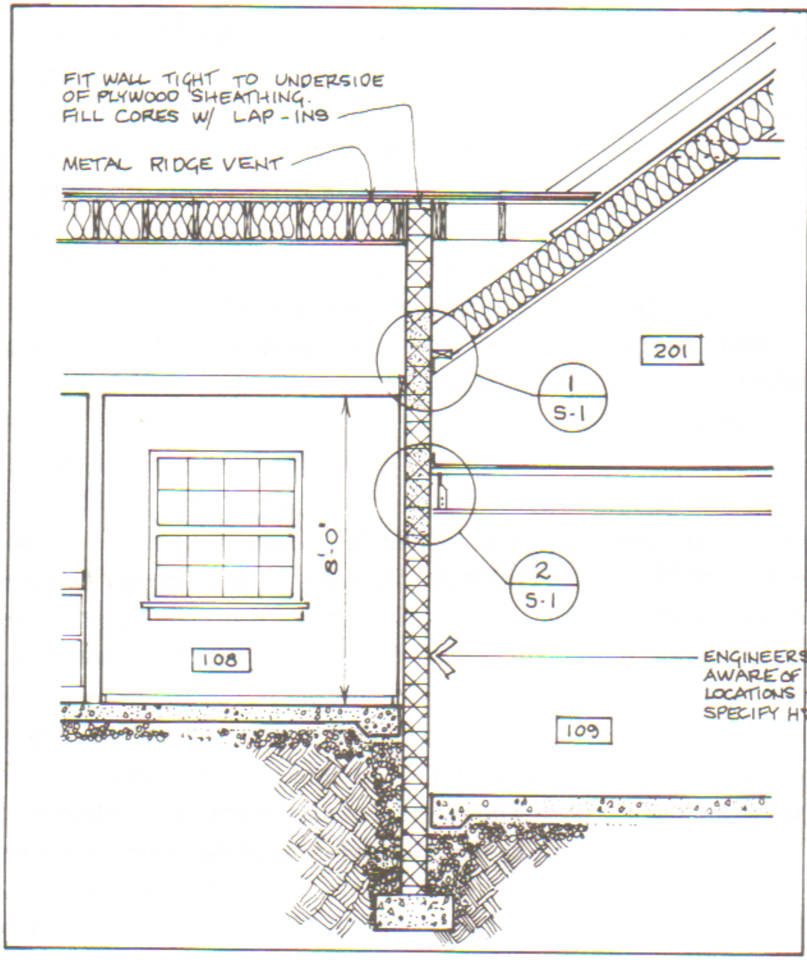
Specifications sometimes indicate one requirement and drawings another. Subparagraph 1.2.3 of the AIA General Conditions, Document A201, states: *The Contract Documents are complementary, and what is required by one shall be as binding as if required by all....* Inconsistencies are not resolved by an arbitrary order of precedence, but must be brought to the architect's attention for appropriate resolution. The AIA General Conditions is clear in regard to the interpretation of the contract documents. Subparagraph 4.2.11 states: *The Architect will interpret and decide matters concerning performance under and requirements of the Contract Documents....*

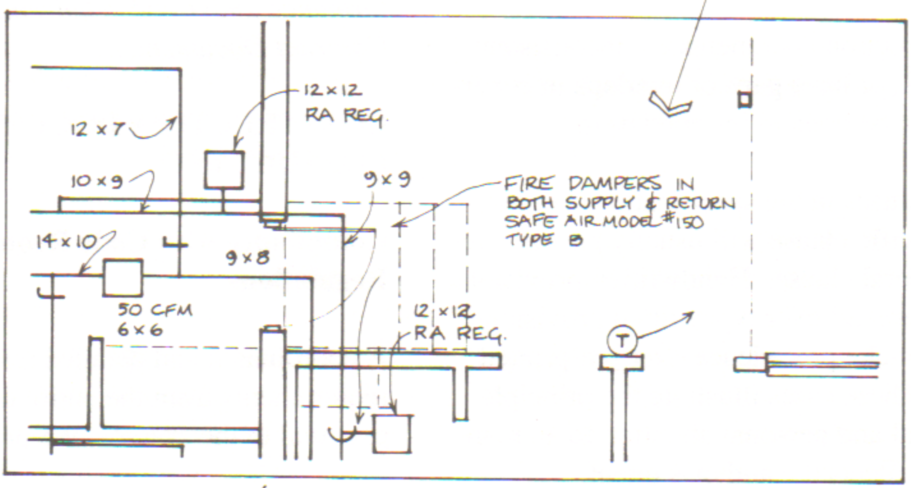
CONSTRUCTION DOCUMENTS OF CONSULTANTS

Compliance with Code Requirements and Regulations

A coordinated and detailed response to code requirements from the entire design team is essential to the success of a project.

Consider, for example, energy requirements. Siting, preliminary selection of materials, and





ARCHITECTURAL/ENGINEERING COORDINATION

schematic organization of programmatic elements are largely within an architect's control. These energy considerations must be balanced against other requirements more closely controlled by others, including structural requirements.

Fire protection also requires building team coordination. The incorporation of interior courtyards or atriums, for example, may require engineering for fire protection. Mechanical, electrical, and plumbing equipment are often critical elements in a fire protection plan. When there are no physical barriers to the spread of potential fires, protection depends upon sensing devices, sprinkler systems, and air handling equipment. These systems and building components are likely to be designed or selected by the engineering and fire protection consultants, rather than the architect.

The mechanical, plumbing, and electrical codes often have provisions that are the same as or that complement the building and life safety codes. These common provisions are generally understood by most design professionals. Architects, however, cannot always be certain that engineers and other consultants have complied with all code provisions. As a practical matter, architects of complex projects may simply inform consultants about which codes are applicable, and ask them to research the detailed requirements. This does not relieve architects, however, of responsibility to meet code requirements. As leader of the design team and the party contracting with the owner for professional design services, the architect has prime responsibility for code compliance. However, each engineering consultant must sign his or her drawings submitted for plan review by the code official and thereby also becomes responsible for compliance. Moreover, the AIA Architect-Consultant Agreement (Document C141) states that the consultant is responsible for code compliance in the same manner and extent that the architect is responsible to the owner.

Initially, architects should verify that each member of the project team is working from the same set of code requirements. Consultants should inform the architect about significant aspects of their work which are required by code. Although codes generally allow several responses to requirements, they occasionally require specific design features. Consequently, architects must know which design elements may change and which may not.

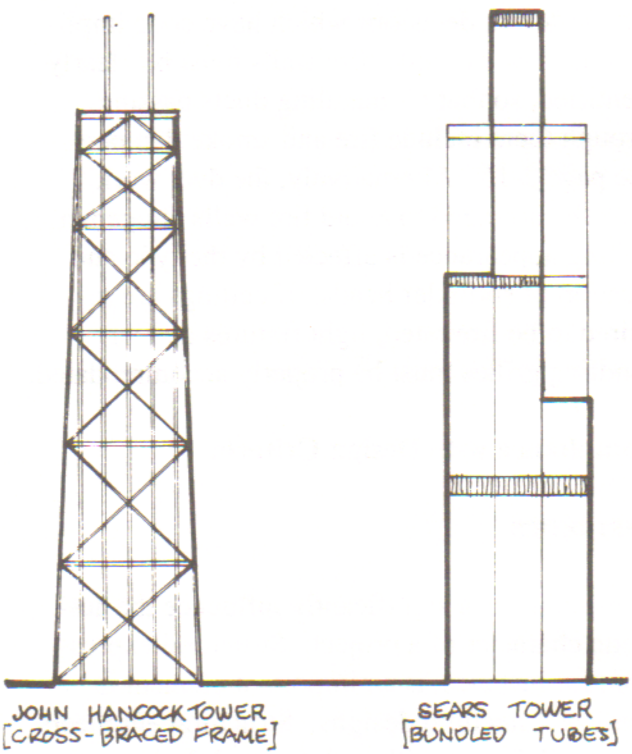
Architects are responsible to notify their consultants of design decisions which have code implications. For example, fire walls must be clearly identified, so that air handling ducts passing through them include fire and smoke dampers. See page 2-16. Alternatively, the duct work could be arranged to avoid fire walls altogether. Ceiling appearance is affected by the type and location of sprinkler heads. If ceilings are required to be fire rated, light fixtures and air handling grilles must be properly accommodated.

Compliance with Design Criteria

Aesthetics

Consultants can significantly influence the aesthetic character of a project. Structural expression, for instance, is an important element in many architectural designs. Structural engineers often collaborate with architectural designers to achieve such aesthetic goals. The structural design of the cross-braced frame of the John Hancock Building and the bundled tube design of the Sears Tower, both in Chicago, are good examples of positive aesthetic qualities achieved through the mutual efforts of architects and their structural engineers. On a smaller scale, the structural design of framing members influences floor-to-floor height, and thus overall building height, by establishing the floor structure's depth. The relationship of spandrels to window openings is often critical to the proportions of a building's facade. In many instances, the basic character of a building is a result of its structural expression, as in a domed structure or an air-supported roof.

Mechanical engineers may influence wall treatments by their response to energy considerations.



STRUCTURAL EXPRESSION IN ARCHITECTURE THE DESIGN OF THESE TWO WELL-KNOWN BUILDINGS HAS BEEN STRONGLY INFLUENCED BY CONSULTANTS TO THE ARCHITECT.

Their work can affect the character of the building's envelope, including its fenestration in relation to solar orientation. On a smaller scale, the location and design of air diffusers can affect the aesthetic appearance of interior spaces. Where mechanical equipment is exposed to view, architects normally ask to review and approve illustrations showing the equipment's physical appearance. Unsightly fans on rooftops can seriously detract from an architect's design.

Electrical engineers, through selection and placement of light fixtures, can affect the aesthetic quality of spaces and ceilings. With the development of open plan office design and the use of task lighting, electrical engineers may also influence the design and placement of partitions, furniture, and equipment. Offices commonly contain video display equipment, computers, communications equipment, and electronic sensing devices for security and fire protection. These items of equipment are generally selected by the electrical engineer, in consultation with the architect.

Food service consultants, lighting consultants, acoustical consultants, and art advisors may also influence a building's aesthetic qualities. Architects must always inform their consultants of design criteria and the aesthetic effects they are trying to achieve. Product data, study models, and photographs may be used to assess intermediate design progress, and are subject to the architect's final approval. Architects must know enough about the details of their consultants' work to maintain design control. At times, they may suggest alternate approaches or solutions more compatible with the desired aesthetic character of the project.

Quality Control

Since many of the construction documents prepared by consultants are based on calculations, quality control is relatively easy to achieve. Parameters are well defined and solutions can easily be checked.

Details that are shown on the drawings must be in conformance with engineering design assumptions. If a structural engineer designs a moment-resisting frame, for example, the joint details must reflect that condition. Architects may review consultants' construction documents to confirm that designs, details, and specifications are compatible with the consultants' calculations and assumptions.

An architect can support a consultant's quality control by informing him or her of all relevant design criteria to which the consultant must adhere, and by requiring the consultant to schedule periodic reviews by experienced senior staff members or *peer review* by others in the consultant's profession.

Although architects can check for internal consistency and for apparent compliance with standards, consultants are primarily responsible for quality control of their own work.

Cost Control

Estimating *initial costs* is an essential part of a consultant's work. The percentage of the total budget allocated to each discipline varies with building type and project scope. Architects often establish budgets for the major elements of construction work for incorporation into an overall project budget. Once the budget is established, consultants are expected to design within its limits. Consultants must, therefore, be accurate in predicting initial costs so that the architect can prepare a reliable overall project estimate.

Because operating costs tend to vary inversely with initial costs, a relatively low construction budget may imply that life cycle costs will be relatively high. Consultants must evaluate conflicting considerations in order to produce optimum design solutions. Likewise, architects must review each alternative to be sure that a consultant's decision serves not only his or her particular discipline, but the project as a whole.

Operational costs may be difficult to calculate. Calculations involve more than the characteristics of specified equipment; they can involve the operating characteristics of the owner's organization and other factors affecting a facility, such as changing climatic conditions. Engineering calculations may, in some instances, be based on assumptions different from actual conditions. For example, a facility may be operated differently than anticipated by its program; calculations may be based on average conditions, in spite of the fact that extreme weather conditions may have been experienced in recent years; or fuel prices may have increased suddenly and unexpectedly.

It is important that basic design assumptions are realistic. Architects should understand the operating characteristics of facilities, and they must ensure that design assumptions are accurate and that designed elements and systems will be appropriate.

Maintenance is an important aspect in the selection of products and systems. Some mechanical and electrical systems are complicated, sophisticated, and sensitive. If properly balanced, they can be efficient and economical. But, they can also be troublesome and more difficult to maintain than simpler, less technically advanced systems. Equipment maintenance costs vary with the size and skill of maintenance staffs. Some design professionals have expanded their practices to include facilities management services, including the preparation of detailed operational and maintenance programs.

Specified systems must be properly installed, reliable, and receive scheduled maintenance to be successful. The architect should determine that such systems are appropriate to the contractor's and building manager's degree of sophistication.

Compatibility with Other Elements

The *size and weight* of equipment is another design consideration. Engineering drawings are largely diagrammatic, making it difficult to verify that design criteria have been met. For example, a large pipe or duct may be represented by a single line on a drawing, but its actual size determines the clearances which must be provided and maintained. Unfortunately, these considerations are sometimes ignored. Architects can create similar problems by providing insufficient space for equipment and services during design development phases. Allotted spaces might prove to be too small, and increasing the building's gross area may be difficult without disrupting the overall architectural solution and budget.

Operational characteristics of mechanical and electrical equipment must be considered by the design team before final selections and placement are made. In critical cases, a special consultant such as an acoustical engineer may be retained to advise the design team on the placement, isolation, and construction of large air handling equipment. Electrical distribution equipment can interfere with the operation of sensitive laboratory or hospital equipment. In this case, the architect may ask the owner to provide the services of a special consultant to advise the design team on the placement, selection, and isolation of certain equipment.

Ease of Construction

Labor and Equipment Requirements

Architects and their consultants should determine that the systems they design can actually be built, considering the space, equipment, and labor required. For example, if a floor system utilizes precast concrete T-beams, there must be sufficient room on the site to position the cranes required to erect these units. If construction access is available from one side of a site only, construction must be able to proceed in only one direction. Post-tensioned structures require accurate placement of tension cables and hydraulic jacks to stress tendons properly. The availability of the skilled and experienced labor necessary for these operations influences the decision to utilize such systems.

Large air conditioning chillers and cooling towers are often placed on the upper stories or roofs of multi-story buildings. If they cannot be disassembled and installed in sections, they must be lifted intact to their final locations. Once in place, equipment and systems may require sophisticated pneumatic and electrical controls and precise balance in order to operate properly.

The installation of sensitive equipment requires the availability of skilled technicians.

In making design decisions, the architect's consultants must consider the limitations of local labor and the availability of special equipment. They must be aware of the implications of applicable union rules. Although contractors must determine the appropriate trade for each part of the work, both architects and consultants should follow established and generally accepted operating procedures, and understand their impact on design decisions.

Sequencing

Engineers and other consultants must see their drawings in terms of the construction sequence as well as the final product. Very large components of mechanical equipment must be brought up to, and placed into, equipment penthouses after they are manufactured. Buildings must remain structurally stable during construction. Once installed, equipment must be accessible for servicing or to remove and replace malfunctioning units.

Architects should review consultants' construction documents with the construction process in mind. The sequence of construction and workability of the scheme throughout the construction process must be considered. Major building elements must fit into place at the appropriate time and without disrupting other ongoing activities.

Scheduling

It may be desirable to order certain components of a building well in advance of their installation. Major HVAC components, large electrical transformers or switchgear, and curtain wall systems are frequently custom made for a particular project. These elements are not generally in a warehouse waiting to be purchased. Even standard catalog items are often manufactured only when specifically ordered and require a significant amount of lead time before delivery.

Architects' consultants must be involved in scheduling to enable major items to be available when needed. Contractors are often selected too late to order long-lead time equipment in a timely manner. One solution is for the owner, on the advice of the architect and consultants, to order equipment directly. When a contractor is subsequently selected, purchase orders are assigned from owner to contractor. Upon delivery, the items are received and installed in the same way as if the contractor had been involved from the beginning.

Fast-track delivery procedures work generally the same way. A project is divided into packages or stages of work, each of which represents a separate prime contract. Starting construction and ordering items before all the construction drawings are completed helps to ensure the availability of products when needed, and tends to control costs during periods of rapid inflation.

Architects must be sure that consultants specify and package items according to proper criteria. Information about a project's ultimate character and configuration may be limited when ordering. Circumstances may change between the time orders are placed, or a construction package let, and the time an item is received, or final drawings completed. An architect must work with consultants to determine important features, while leaving other aspects open to inevitable change. This may result in excess capacity in equipment or the need to alter designs to integrate with equipment or items already ordered.

Consultants must also be aware of overall construction schedules and, within these schedules, pertinent installation periods. If a new chiller or cooling tower is required before summer, or a new boiler or heating plant before winter, engineering designs must allow equipment to be built and installed in time. Or, if construction must occur during winter months, structural engineers may want to avoid the use of reinforced masonry, which requires special measures to protect mortar from freezing.

These concerns are especially applicable to renovation projects. An old system may have to be changed to a new one, or an owner may require that a new wing or suite be ready before the old one is abandoned. Some considerations will be apparent from construction documents, while others will not. Architects must be certain that timing has been considered and is realistic.

An owner may rely upon the architect and the architect's consultants for pre-construction services such as cost estimating, scheduling and sequencing, and reviewing ease of construction. With the advent of fast-track and other sophisticated methods of procurement, some owners have retained *construction managers (CMs)* to provide these pre-construction services. The construction manager joins the project team during the design phases and either remains as an adviser or becomes the constructor as well.

Internal Coordination of Consultants' Documents

The architect is the prime professional under contract to the owner, and as such, liable for his or her consultants' work. Prudent architects, therefore, try to make certain that their consultants provide appropriate levels of professional service. There are some practical limits, however.

One limit is that architects cannot check each consultant's documents for internal consistency and coordination. That is the responsibility of each consultant. If an electrical engineer specifies one type of lighting fixture, the drawings should not show another. Dimensions should be accurate and drawings and specifications should be coordinated. The AIA Architect-Consultant Agreement (Document C141) specifically requires the consultant to be responsible for coordinating his or her own work.

When a consulting firm combines more than one engineering discipline, coordination becomes more complicated. For example, structural, HVAC, plumbing, and electrical work may all be done in different departments of the same consulting firm. Generally, a consultant's documents must be made internally consistent by that consultant. Structural and mechanical documents must be checked against each other for conflicts prior to being sent to the architect. Someone in the consulting firm must be responsible for this interdisciplinary checking.

Overall Coordination of Consultants' Documents

Format for Specifications

Specifications prepared by an architect and his or her consultants are bound together into a Project Manual. All the work of the individual parties must be coordinated to produce a unified document, not a collection of individual parts. To accomplish this, architects establish formats for consultants to follow.

Coordination extends from simple considerations, such as the color of the paper on which the specifications of different consultants is printed, to the format and numbering system used. The consultants' input to bid forms, including instructions to bidders, and to Division One, the general requirements of the specifications, must be established. Overall, each consultant's work must be coordinated with that of the architect and the other consultants.

The architect must require that his or her consultants participate in the preparation of the requirements of Division One, so that their individual specification sections are appropriately coordinated. The architect is the one professional on a project team with the required perspective to coordinate the many diverse elements of a Project Manual.

Diagrammatic Mechanical and Electrical Drawings

Most construction documents prepared by mechanical and electrical consultants are diagrams or schedules. HVAC drawings show dimensions of ducts. Major pieces of equipment are shown, but other physical conditions are not represented. Duct dimensions may not include the thickness of required insulation. Electrical documents are more diagrammatic. Typically, wiring is indicated in floors or in ceilings, as are home runs to panelboards. Actual conduit locations, however, are usually determined by contractors in the field. Plumbing drawings are less diagrammatic than HVAC and electrical drawings, but pipes and fittings are not drawn to scale. The exact location of piping may be determined by the contractor in the field.

While these different methods of representation are logical, checking and coordination is difficult. Architects can overlay drawings of the various consultants to spot potential conflicts. Even where lines do not cross in such overlays, this does not guarantee adequate clearances, since the diagrams may not be precise enough. Overlay drafting and CAD make it easier for architects to identify and resolve conflicts before they become construction problems.

Serious construction problems may be caused by uncoordinated drawings. Contractors may have problems installing mechanical ducts and electrical conduits within the space actually provided. For example, walls may be framed without adequate space for plumbing lines. Architects must address such potential problems when checking the consultants' documents.