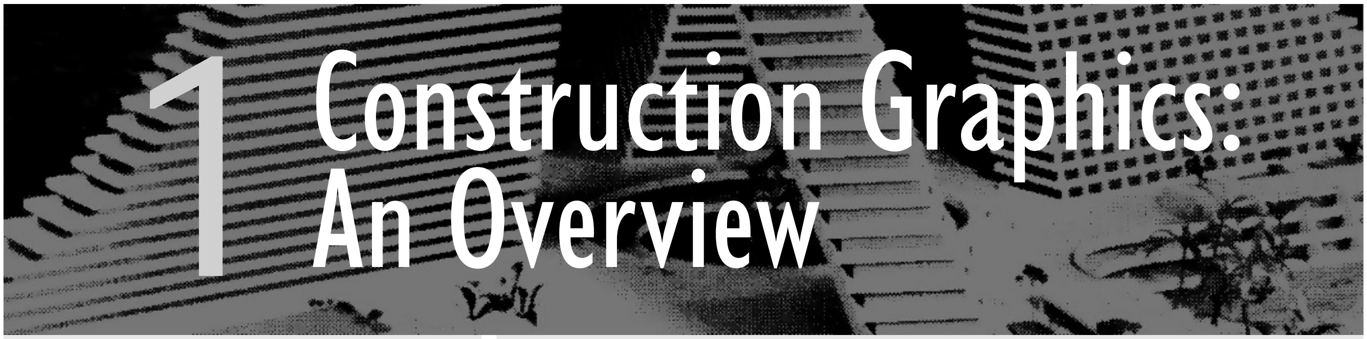

1 Construction Graphics: An Overview

Key Terms

American Institute of Architects (AIA)
Architect/engineer (AE)
As-built drawings
Building codes
Computer-aided design and drafting (CADD)
Construction Specifications Institute (CSI)
Dead load
Delivery systems
Design-build
Design contract
Dynamic load
Engineering contractor
General building contractor
Geotechnical report
Hardscape
Hydrostatic load
Integrated services delivery
Live load
National Cad Standard (NCS)
Planning codes
Prime contractor
Prime design professional
Shop drawings
Specialty contractors
Static load
Substructure
Superstructure
Temporary structures
Value engineering
Work breakdown structure
Zoning codes

Key Concepts

- The probability of differences arising between people engaged in an endeavor rises exponentially with the number involved, as demonstrated by the following formula: 2^{n-1}, where n is the number of participants and 1 is the single circumstance in which all participants agree.

Objectives

- Describe many of the challenges that design professionals face in their work.
- List the principal participants in a construction project, and identify their roles.
- List and describe the principal categories of construction project.
- Describe the typical educational path of architects, engineers, and contractors.
- Differentiate the design professional's and constructor's responsibilities.

Introduction

Graphics are indispensable to anyone trying to communicate a vision or describe an object to an audience. Ideas commonly originate as pictures, which their creators then translate into words or words and pictures when they want to share them with others (see Figures 1.1a and 1.1b).

Indeed, combining pictures with words is the only reliable way to describe some objects, particularly complex ones such as machines, buildings, and other structures. Because professionals involved in designing construction projects must communicate particularly complex ideas, they typically do so through graphics. Therefore builders—whose responsibilities include interpreting the drawings and other documents that design professionals create, determining the means and methods of construction, and executing construction work in a safe and profitable manner—must have a thorough understanding of the graphics commonly used in construction projects.

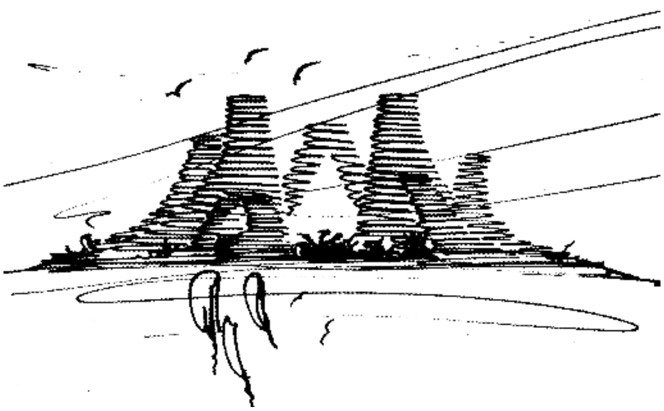

Figure 1.1a Graphics are used to give life to a design concept, which may grow out of simple sketches such as this. (Sketch courtesy of the estate of Victor H. Bisharat.)

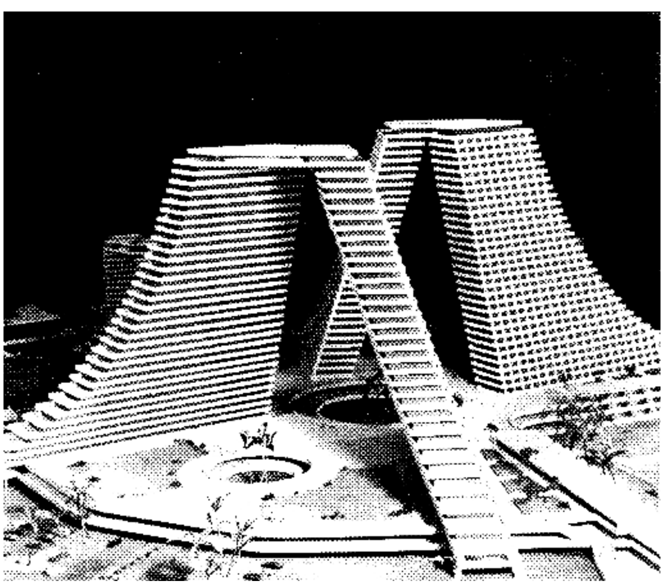

Figure 1.1b The sketch takes model form after considerable design work has been executed. (Photograph courtesy of the estate of Victor H. Bisharat.)

Graphics and Builders

In the course of executing their work, contractors use drawings, specifications, and other documents extensively, and are responsible for producing shop drawings, as-built drawings, and drawings for temporary structures. They are responsible for effectively communicating work requirements to their employees and subcontractors. Constructors who fully understand the project they are planning to build and can effectively communicate the processes required to build it, orally, graphically, and in other ways, dramatically reduce the risk in the undertaking. Those who are alert to what the design professional is trying to achieve in a project and can offer less costly solutions to the design without compromising its integrity—a process known as *value engineering*—give themselves a significant edge over their competitors. Additionally, the increasing popularity of the design-build project delivery system (*integrated services delivery*), which requires the design professional and constructor to collaborate on the design from the inception of a project, suggests that the constructor who is attuned to the interests and concerns of the design professional will be a sought-after partner.

Challenges Facing the Design Professional: Telling a Complicated Story

Architects and engineers have the very challenging task of conceiving solutions to the complex design problems their clients have, then communicating them to the people who bring the project to reality. They face a staggering number of issues in the course of their work. Every client has a unique set of requirements to identify, evaluate, and accommodate. Although they often borrow ideas from other projects, many architects develop solutions from "out of the blue," that is, from their imaginations. Their concepts are usually a melding of the owner's needs and their own artistic proclivities. Architects are well aware of the publicity associated with their work—after all, buildings are the most visible art—and this awareness frequently affects their decision making. Indeed, the principal criterion for selecting a particular architect is often the architect's design "signature."

During the design development stage, in addition to the owner, myriad permitting authorities and community groups have the opportunity to influence a project's design. For example, a project located on a major waterway within a large city might involve 10 or more public organizations—federal, state, and local agencies—that have jurisdiction over various aspects of it. In some jurisdictions, this means that the architect must develop a photograph of a prospective building design and insert it in a digitized photo of the neighborhood, so that planners can evaluate its visual impact prior to approving it. The context of a project requires the design professional to consider, for example, the effects that weather and surrounding buildings will have on a building project—or, in the case of a bridge, such considerations as traffic flow, kinesthetic effect, and safety. The size and configuration of a site, access and egress to it, and even the nature of its soil play a significant role in the project design. The single greatest influences on projects are the time and money that owners allocate to them. And construction as an industry is unique—tens of thousands of parts must be transported to and assembled on the site by armies of skilled workers, directed and supervised by management teams that change with every project. Consequently, no two projects are exactly alike; all are prototypes.

Recent developments in computer technology enable architects to develop highly unusual designs—projects so unique as to be impossible to draw using conventional board drafting methods (see Figure 1.2).

Although computer-aided design and drafting (CADD), when employed to take advantage of its strengths, has contributed significantly to document production, it is commonly used to produce the conventional two-dimensional depictions of the project (the drawings). The full capabilities of existing software, including its potential to produce dimensionally sound pictorial representations of the project, have yet to be widely used.

Figure 1.2 The Experience Music Project in Seattle, Washington, represents a growing genre of projects that will test the ingenuity and skill of the construction community. (Frank Gehry, Architect; Hoffman Construction, Contractor; photo by the author.)

Computer software companies are currently developing and refining programs that potentially will give designers and builders much more effective control over the design and construction processes. Formerly called "intelligent building models" (variously dubbed "parametric modeling" or "object-oriented" programs) and "object linking and embedding technology" (OLE) and now more commonly referred to as BIM (Building Information Modeling), this software enables the user to define and store detailed parameters of building assemblies (such as foundations, walls, ceilings, and equipment) within the drawings. This makes retrieving many kinds of information quick and easy. BIM software creates a digital building model, a substantial database that correlates myriad building features to graphic images, and it holds significant advantages for design professional and builder alike. Chief among them is the linking of related elements, components, or systems in the digital model. In conventional board drafting or CADD-produced drawings, the potential for discrepancies within drawings is high: changes made in one drawing must also be made in all the other drawings in which the subject of the drawings is depicted, and even in a modest project that could mean making changes in 5, 10, even 15 drawings or more depending on the nature of the change. Imagine the effect of changing the location of a key structural column on the ground floor of a 30-story building to please a major lessee! All the related architectural drawings and especially the structural drawings have to reflect the change.

In drawings produced with BIM software, changes on one drawing are automatically made in the related drawings. That same linking enables the user of the digital model to take sections wherever it is desired. The "anatomy" of the project at any place within the model is visible—the builder is no longer dependent on the judgment of the design professional to select the location of major and minor building sections. One of the key challenges presented by conventional drawings—seeing a three-dimensional object (in the mind's eye) using a series of contiguous two dimensional depictions of it—is more easily overcome by a model (digital or otherwise). Another feature of BIM, justifiably touted by its proponents, is what is known as "clash detection"—identifying the locations where two elements (say an HVAC duct and a structural member) erroneously occupy the same space. Such clashes are not unusual in the interstitial space (between suspended ceilings and the floor above) of commercial buildings. When integrated with scheduling software, a 3D digital model is a useful analytical and training tool (dubbed 4D CADD). Mechanical specialty contractors, who seem to be leading the application of 3D modeling to their work, translate standard two-dimensional drawings into a 3D model for use in component manufacturing (Computer Integrated Manufacturing) and for billing and inventory purposes.

As with other technology though, BIM is not without drawbacks, including the need for electrical power and expensive computing equipment, the costs of user education, a fairly steep learning curve required for proficiency, and a lack of realism. The conceptualization value of a model may help builders understand the design professional's instructions more readily (assuming the instructions are well done), but understanding what one is being directed to build is overcoming only half the problem. Contractors will still need to develop the construction plan, collect and organize all the resources required to build the project, and lead the complex and diverse team of participants to a timely and profitable conclusion. It is worth noting that this technology appears to work best when the *prime design professional*, design consultants, the builder, and key specialty contractors collaborate early in the design development stage. (Some owners mandate the use of BIM and a delivery system that involves contractors early in the design process—refer ahead to page 13 for an explanation of delivery systems.) Thus BIM may have more of an impact on delivery systems and interdisciplinary collaboration than on the construction process itself. It is worth mentioning that the involvement of more parties early in the design phase introduces design liability issues that may take some time to resolve.

The form that construction drawings take in the future—and the medium used during construction—remains to be seen. For the time being, however, architects and engineers continue to produce, on paper, two-dimensional depictions of the projects they design even when BIM is used in the project design. These influences make it easy to understand why the design and construction professions are error-prone and why they will remain lively fields of practice in the future.

Dialects and the Standardization of Drawings

It is useful to think of construction graphics as a language that participants in the construction process must "speak" fluently, even if with varying "accents." As oral communication varies with the individual using it, so does graphic communication. Consequently, we see considerable variation in how drawing sets are organized, how each sheet is formatted and annotated, and how graphic symbols are used. This lack of consistency adds difficulty to an already complicated process and increases the potential for misunderstandings between builder, owner, and design professional.

The publication of the first *Architectural Graphic Standards (AGS)*, written by Charles George Ramsey and Harold Reeve Sleeper in 1932,[1] was an early effort to standardize graphics for construction projects. Today, *AGS* is a widely used compendium of planning, design, construction, graphic, and other reference information that focuses primarily on design data. *ConDoc*, developed by Onkal Guzey and James Freehof of the American Institute of Architects (AIA), the principal professional organization of the architectural community, is a design presentation standard that offers a uniform drawing set organization, sheet format and numbering methodology, and a keynote system that facilitates the prompt communication of graphic and specification information. Though *ConDoc* has contributed significantly to better quality control and drawing productivity, it is not universally employed. Many design offices insist on using their own formats and drawing set organization.

As recently as 1990, the Construction Specifications Institute (CSI) discovered that few standards related to construction drawings actually exist. Having had considerable success with its MasterFormat indexing system (a widely used list of construction products and activities oriented toward how parts are specified, purchased, and installed), CSI turned its attention in 1994 to developing a single construction drawing standard, which it named the *Uniform Drawing System (UDS)*. The *UDS* has become a fundamental part of the *National Cad Standard (NCS)*, an evolving collaboration of CSI, AIA, the U.S. Department of Defense Tri-Service CADD/GIS Technology Center and the United States Coast Guard, the Facility Information Council of the National Institute of Building Sciences (NIBS), the U.S. General Services Administration (GSA), and the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA). These organizations signed a memorandum of understanding in 1997 to develop and promulgate the use of the NCS. The Facility Information Council of NIBS provides the forum for the effort; CSI is contributing its UDS, the AIA its CAD layering guidelines, and the Tri-Service CADD/GIS Technology Center its plotting standards. The NCS is a much-needed single standard for the organization and presentation of drawing sets; a format for individual sheets, schedules, and diagrams; and standards for color, keynotes, material symbols, and CAD layering.[2] Though not yet widely used, the NCS is a work in progress that is gaining acceptance.

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[1] Ramsey and Sleeper (2000).

[2] National Institute of Building Sciences/American Institute of Architects/Construction Specifications Institute/Tri-Service and the U.S. Coast Guard (2001).

Participants in the Design Process: Owners, Design Professionals, and Contractors

Designing and constructing projects frequently involves hundreds of participants; however, there are three principal players in every project: the owner, the design professional, and the contractor.

Owners

Although the list of potential construction project owners is nearly infinite, the short list includes governments (federal, state, and local), districts (school, irrigation, and reclamation), for-profit and nonprofit corporations, partnerships, and individuals. Construction projects occur when a representative of one of these groups seeks to mitigate a need or realize an idea. The owner's role generally is to provide the site; finance both the design and construction of the improvements; give timely, accurate feedback to the design professional; and operate the facility. Owners commonly engage the services of a design professional to conceive the design and produce the construction documents. Owners place contractors under contract to execute the work described in the construction documents.

The Design Professional and Design Consultants

Design professionals—primarily architects and engineers—offer a wide variety of services to project owners. Traditionally, they have created projects and produced construction documents and contract administration on behalf of owners, under service agreements called *design contracts*. The tumult in the design profession in the last couple of decades has prompted architects and engineers to diversify the services they offer for a fee. Many now include facility life-cycle analysis, recycling and management, as well as practice management in the range of services they provide.

The number of different design professionals involved in producing construction drawings varies according to the type and complexity of the project. Individuals or very small organizations generate most drawings for homes. In some states, laypersons may design homes and duplexes without a design professional's license. Developing the design for a hospital, performance center, or a manufacturing facility, in contrast, may require many highly specialized design professionals who, after rigorous examination, have been licensed by the states in which they do business.

The core participants commonly responsible for the design of building construction projects include architects and landscape architects, and geotechnical, civil, structural, mechanical, and electrical engineers.

Architects, whose authority to design projects derives from state licensing boards, have the daunting task of identifying their clients' problems during the predesign phase and describing their solutions to them, using pictures and words, during the design phase. Architects conceive the physical attributes of a project and incorporate local land-use ordinances and applicable building code requirements into their designs. Their interests and professional responsibilities are focused primarily on how a project looks (esthetics) and how it works as a product (that is, will it protect its users from the elements and from injury during catastrophic events such as earthquake and fire? Does it fit effectively into its environment? Does it fulfill the owner's needs?).

The number of specialists and the variety of services that design consultants offer is substantial; however, architects commonly hire structural, mechanical, and electrical engineers for significant portions of building design work—areas of specialty for which they frequently do not have the training, license, or personnel. Large design firms, however, frequently have in-house engineering capability, which gives them more market share, greater efficiency, and more control over the design process. Such organizations are commonly referred to as *architect/engineer* (AE) firms. Regardless of the size and organizational structure of the office, the overall responsibility and liability for the design of a project reside with the architect, who becomes known as the *prime design professional* (the "prime" designer or contractor is the term given to the entity that signs a contract with the project owner).

Although many civil engineers are qualified to prescribe the treatment required to prepare soil for a project, geotechnical engineers are registered professional engineers who are required to devote several more years to practice and/or additional education after becoming licensed civil engineers before they can legally call themselves Geotechnical Engineers. They are hired by owners to investigate a project site and produce a comprehensive evaluation of its soil conditions, which are recorded in a geotechnical report. Geotechnical engineers commonly investigate the past uses of a site and its hydrology, identify its soil types, determine whether and to what extent a site is contaminated, and delineate any procedures that the contractor must follow to prepare the soil for its intended role. For example, soils must be made stable and competent to bear the weight of structures and vehicular traffic for years, and soils may be used to encapsulate solid waste and to line excavations and earthen structures that will contain water.

A host of participants in the design and building process use the geotechnical report. The structural engineer uses the report to design the foundation of a structure; the landscape architect uses the report to develop the specifications for the planting and irrigation of landscaped areas; and the contractor and subcontractors use the report to determine the costs of earthwork (such as excavation, soil preparation, pile-driving, and foundation work) and evaluate the risk associated with it.

The principal concern of geotechnical engineers is how the soil will perform over time with the planned activities imposed on it. Their contracts with the owner normally require them to prepare the geotechnical report, and monitor, inspect, and approve earthwork while it is being performed. Additionally, the geotechnical engineer resolves issues that arise in the course of construction, such as the mitigation of contaminated soil that might not have been apparent during the site investigation. Beyond these functions, they do not typically get involved in design.

Civil engineers typically produce most of the construction documents related to engineering construction (streets and highways, sewer and water treatment plants, harbors, dams, bridges, and utilities). They must be licensed by the state in which they perform design work. On commercial building projects, the civil engineer plays a relatively limited design role, normally taking responsibility for on-site grading, drainage, and paving plans and specifications; for off-site improvements (driveways, gutters, curbs, and sidewalks along a public thoroughfare); and for the design of certain on-site underground utilities (sewer lines, fire system supply, storm drainage, domestic water supply). Civil engineers often cite the standard specifications of the city, county, or state in which the project is located, particularly in the design of off-site improvements. These specifications are frequently tried-and-true specifications that are developed by state departments of transportation (which invest considerable funding in research) and are often wholly adopted by public works departments at the local level.

Structural engineers specialize in the design of foundations (piles, caissons), substructures (habitable portions of a structure that are below ground, such as basements), and superstructures (the portion of the project above grade, or above water in the case of bridges built across bays, lakes, and rivers). Like civil engineers, structural engineers are licensed by the states in which they do business, but they are frequently required to have specialized education and training beyond that of the civil engineer. Structural engineers—frequently hired by architectural firms for their expertise—are focused on the performance of the structural system under various loading conditions that fall under two classifications—static and dynamic loading. Static loading comprises dead loads (gravitationally imposed loads resulting from the weight of the structure and its permanent equipment) and live loads (mobile loads that are not necessarily present at all times). Furniture, snow, hydrostatic pressure (the pressure at any point exerted on a surface by a liquid at rest), and a building's occupants are examples of live loads. Dynamic loads, such as seismic activity and wind can occur suddenly, and they vary in intensity, duration, and location.

Structural engineers are responsible for protecting the lives and property of project users in a cost-effective way. Although their focus is on the performance of a structure under the loading conditions just mentioned, they should also be aware of the esthetics of the project.

Mechanical engineers involved in building project design are responsible for plumbing, sewerage and piping systems, and for heating, ventilating, and air conditioning systems (HVAC). Mechanical engineers commonly form consultant agreements with the A/E to develop and describe the plumbing and HVAC systems in buildings, which are designed to ensure the comfort and health of building occupants. Plumbing and sewerage systems provide an adequate source of water for human consumption and sanitation, and effectively dispose of wastes generated in the building. The heating, cooling, ventilating, and air conditioning equipment is used to control environmental comfort factors such as the temperature of the ambient air in a building, the mean radiant temperature of the surrounding surfaces, the relative humidity of the air, pureness of the air, and air motion. HVAC and plumbing systems in building projects present a significant design challenge, particularly in the distribution of conditioned air and piping through the structure. The involvement of mechanical engineers in the design process increases dramatically when they are involved in industrial construction projects, such as refineries, manufacturing facilities, chemical plants, waste and water treatment plants. Indeed, they may hold the prime

"The qualities that most clearly set architecture apart from other established professions are its close ties to the arts and its similarities to artistic endeavors. Creativity is crucial to all professions, but for the architect it is of the highest priority. Moreover, architects produce objects that are fixed in space, highly public, and generally long lasting.

—DANA CUFF, PH.D., *Architect's Handbook of Professional Practice*, 12th edition (American Institute of Architects, 1994)

"It is generally recognized that an architect is a combination of artist and engineer, with the 'art' aspect emphasized . . . most architects have an initial and abiding concern about a project's aesthetic appeal, impact, and propriety.

—RALPH LIEBING, *Architectural Working Drawings*, 4th edition (Wiley, 1999) design professional role on these projects. Mechanical engineers concentrate on the performance of the systems they design.

Electrical engineers are involved in the design of a variety of construction projects, including massive power generation and distribution systems for state and federal governments, cogeneration power plants, and building construction projects, to name a few. As with the other engineers, electrical engineers must be licensed by the state in which they conduct business. In building construction projects, these engineers design the electrical service and communications systems on the site, as well as the site lighting, usually at the request of the A/E. They also design the service and distribution systems inside the structures. In addition, electrical engineers must design and clearly spell out the type and location of electrical equipment and cabinetry and the means of distributing and controlling the power. Those engineers who work for the local utility company frequently control the design of the off-site system (the portion found in public utility easements). Electrical engineers focus on the proper sizing of the system, the location of the equipment, the distribution of the power, and the safety of the end user.

Landscape architects, also licensed by the state, specialize in developing ornamental landscaping plans, which includes selecting trees, shrubs, ground cover, and grasses, and designing the irrigation system required to support them. The landscape architect's work may also include some site improvements (such as walkways, garden structures, screens, fencing, and water features, all of which are referred to generally as *hardscape*). Landscaping plays an important role—not only for the visual beauty it brings to a project, but for the beneficial effects that a well-conceived and -executed design can have on the energy consumption of a building, as well as on air and water pollution.

Contractors

Although the term "contractor" is loosely applied to anyone who earns income from constructing things, sole proprietorships, partnerships, corporations, and joint ventures are the common legal entities that assume responsibility and liability for constructing projects under contract with the owner. Many states regulate contractors through licensing boards, which assure the health, welfare, and safety of the public through education, testing, and, where applicable, the enforcement of state license laws.

There are distinct categories of contractor:

- ***Engineering contractors*** construct engineering projects such as highways, bridges, and industrial construction projects.
- ***General building contractors*** produce residences, multiple-family projects, commercial and civic buildings, and/or retail spaces.
- ***Specialty contractors*** focus on one portion of a project, such as plumbing, sheet metal and air conditioning, roofing, insulation, tile, floor coverings, or elevators.

The contractor who signs a construction contract with an owner is called the *prime contractor*. The prime contractor, for a variety of reasons, frequently hires specialty contractors for portions of the work, who become subcontractors under the construction contract. Plumbing, mechanical, and electrical specialty contractors are commonly hired in this fashion.

Varying Professional Viewpoints: Legal Responsibilities, Education, Training, and the Consequences of Diversity

The term "professional" has numerous definitions, among them "engaged in a specific activity as a source of livelihood," "performed by persons receiving pay," "and having great skill or experience in a particular field or activity."[3] The term is commonly used simply to describe anyone being paid to do something. However, as it pertains to architects, engineers, lawyers, doctors, and now many construction people, "professional" means "one who has an assured competence in a particular field or occupation" as determined by education, training, and rigorous examination.

Education of the Design Professional

An architect or engineer can follow any of several paths to professional registration; however, the common one is formal postsecondary education in an accredited architectural or engineering program. Long and often arduous courses of study, architecture and engineering programs prepare students for internships after graduation from college, which qualifies them for registration board examinations. In the case of architecture program graduates, the internship must be acceptable to the governing jurisdiction: Acceptable usually means three years in an environment that requires "diverse experience" (practice in a variety of areas), after which the professional exam may be taken.

Individuals desiring an engineer's license must acquire six to eight years' work experience, depending on the state, and must pass the Fundamentals of Engineering (FE) exam to become an Engineer in Training and to qualify for the Professional Engineer (PE) exam. Credit against the work experience requirement may be granted for academic study in an accredited engineering program, but some work experience is required.

[3]The definitions in this paragraph come from the *American Heritage Dictionary of the English Language*, Houghton Mifflin Company, 2000.

Geotechnical engineers must have four years of "responsible charge" in geotechnical engineering after licensure as a civil engineer to qualify for the geotechnical engineering exam. Structural engineers must have three years of work experience in structural engineering after licensure as a civil engineer in order to sit for the Structural Engineers' (SE) exam. Passing these exams gives examinees the authority to use the title Geotechnical Engineer or Structural Engineer in their practices. Additional benefits are conferred on holders of SE licenses; in California, structural design work on schools and hospitals is restricted to this class of engineer.

Engineering and architectural programs approach education from considerably different directions. In general, however, architectural programs are distinguishable from engineering programs in that they incorporate liberal studies, design, and architectural theory and history with the physical sciences, mathematics, and technology. Engineering students are normally required to go into greater depth in physics, chemistry, mathematics, and engineering classes than do their counterparts in architecture. They consequently have less time for liberal studies. While generalizing has its drawbacks, architectural education is a "generalist" education that encourages a holistic view of problem solving, with design and human behavior at its center. Engineering education, on the other hand, focuses on physical phenomena and the behavior of systems.

Education of the Contractor

Construction is one of few industries in which people with little education, minimal money, and limited experience can still find good compensation either as employees, vendors, or contractors. In some states, it is possible to build without a license. States that regulate the industry frequently require license applicants to demonstrate the requisite experience, knowledge, and financial wherewithal to contract for construction services.

Owners, partners, and managing employees on commercial building, heavy and highway, and industrial construction projects tend to hold baccalaureate degrees in construction management, civil engineering, architecture, or allied fields. The past several decades have seen an increase in the number of educational institutions offering construction management as an academic pursuit, replete with accreditation boards that assure the academic quality of the programs. Still in their infancy, construction management programs vary widely in their curricula, but are similar to architecture and engineering programs in their duration and level of difficulty.

Professional Licensing

As noted, many states regulate contractors through license boards, but until 1996, no professional licensing body existed for contractors. In 1994, the American Institute of Constructors (AIC), the professional organization representing the construction management discipline, undertook to institute a professional licensing program similar to that of civil engineers. By 1996, AIC had developed its exams and began testing in numerous sites across the nation. AIC's Certified Professional Constructor (CPC) program includes verification of an appropriate education or equivalent experience and practice at an advanced level, prior to applicants' sitting for two rigorous examinations, either the basic or the advanced CPC exam.

> **"Contractors do not know the thinking, reasoning, and rationale behind the design and documentation of the project."**
>
> —Ralph Liebing, *Architectural Working Drawings*, 4th edition (Wiley, 1999).

Consequences of Diversity

A professional education is as much a socialization process as it is an educational process. Consequently, students of various disciplines learn the values of the group they choose to join. These values manifest themselves in how each participant in the construction process views the others, and are frequently the source of conflict and misunderstanding. It is well worth the effort for each of these professionals to understand the values of the others; all are codependant and play equally vital roles in the construction process. Accepting that the differing responsibilities and proclivities of each participant are likely to manifest themselves in their work is a critical step to cooperation and productivity on a construction site.

Design Professionals and Contractors: A Comparison

The management responsibilities of the prime design professional and prime contractor are similar in many ways. The differences between them tend to occur in their professional responsibilities.

The prime design professional assumes responsibility and legal liability for managing the design process and its outcome (the contract documents), whereas the

> **"Architects tend to have a more global or overall view and concept of a project; many consultants become totally engaged in their narrow realm of work, without thinking of others."**
>
> —Ralph Liebing, *Architectural Working Drawings*, 4th edition (Wiley, 1999).

> **"The CAD system has been wonderful for architects. But do they know how to build what they're drawing? Constructability is one of the biggest problems I find."**
>
> —George M. Grant, V.P, Halmar Builders, in the article "Listening to Contractors," *Architectural Record*, February 1998.

constructor assumes responsibility and liability for the construction process and its product (the project as described by the architect). The prime design professional transcribes clients' needs and desires into a form that is commonly used by the builder (drawings and specifications). Builders translate the designer's work into discrete processes to which a value in time and money can be assigned, then set about executing the work safely, to the prescribed quality, and within the allotted time and budget. Each hires specialists for portions of the work. For building projects, architects are commonly the prime design professional, and may hire design consultants such as structural, mechanical, and electrical engineers. Builders commonly are prime contractors, and they also hire specialists for parts of the work, who are commonly known as *subcontractors*. The designer evaluates materials in terms of their performance characteristics and esthetic value; contractors evaluate materials in the context of their effects on costs and the installation process, as well as their performance characteristics. The prime design professional determines *what the project will be*; the prime contractor determines *how it will be constructed*. Both make necessary changes to the processes they control so that the resulting project will be as close to what was planned as possible.

Summary

Both graphics and text are required to successfully describe and construct even the simplest construction project. Graphics are particularly effective for size and shape description and the correlation of elements, components, and assemblies, and they represent a significant portion of the design professional's work. Text is critical to qualitative aspects of a project; in fact, it is virtually impossible to describe the quality of a component graphically. Due to the technical complexity of most projects and the numerous and varied participants in design and construction processes, ambiguity, errors, and omissions exist in the documents and in the correspondence related to them, even under the very best of circumstances. Misunderstandings are, therefore, a common occurrence. Without good graphic, written, oral, and listening skills, as well as respect for project participants and a results-oriented philosophy, owners, design professionals, and constructors alike will doom a construction project to unnecessary conflict.

CHAPTER I EXERCISES

1. Explain what the roles of the owner, design professional, and contractor entail in construction projects.
2. How do the perspectives of the contractor and design professional differ?
3. By what means do contractors and design professionals perform specialized aspects of their work?
4. List the common design professionals involved in construction projects.
5. Prepare a list of questions or discussion items pertaining to design and construction and attend a monthly meeting of the local chapter of the Construction Specifications Institute, the American Institute of Architects, the American Society of Civil Engineers, or builders' organizations. These organizations are very interested in students; in fact, many have student chapters on university campuses, and schedules of events are frequently listed on Web pages. For students with time constraints, CSI meetings may be the best use of time, as CSI's membership runs the gamut of participants in the design and construction processes: construction product vendors, architects, consulting engineers and builders. Members are generally very willing to share their views on the design and construction professions.