PROJECT MANAGERS IN THE CONSTRUCTION INDUSTRY

by

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ABSTRACT

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Submitted to the Department of Civil Engineering on January 24, 1973 in partial fulfillment of the requirements for the degree of Master of Science.

An investigation was undertaken to develop a composite picture of the project manager in the construction industry by:

1. Identifying the project managers in the construction industry,
2. Determining characteristics of their educational and professional backgrounds,
3. Identifying the role of the project manager,
4. Identifying the skills and areas of knowledge which are important to the project manager.

A description of the construction industry is presented as part of the framework within which the project manager must operate. Descriptions of the life cycles of the most significant project types are also presented. From information gathered from a survey of the construction industry, descriptions are developed of project managers in each of nine important types of organizations: owner, developer, architect, engineer, contractor, design/constructor, public highway agency, public building agency, and public heavy construction. A general description of the project manager in the construction industry is developed.

Thesis Supervisor: William A. Litle

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Acknowledgement

I would like to acknowledge the assistance and guidance given throughout the research and analysis of this paper by Professor Litle and the members of the Project Management Committee in the Department of Civil Engineering. In addition, I would like to recognize the James A. Henderson Memorial Fund, which has supported this and other research in project management. Special appreciation must be extended to the participants in the survey for their efforts in completing the questionnaire which forms the basis for the conclusions presented in this paper. Finally, I would like to express my gratitude to Miss Joan Whitehead for her assistance in conducting the survey and to my family for their support during the preparation of this paper.

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CHAPTER 1

SUMMARY

I. Introduction

The purpose of this investigation was to develop a composite picture of the project manager in the construction industry by answering the following questions:

1. Who are the project managers in the construction industry?
2. What is the characteristic of their backgrounds?
3. What is the role of the project manager?
4. What skills and substantive areas of knowledge are important to him in his role as a project manager?

In order to develop a composite picture of the project manager in the construction industry, three detailed investigations were undertaken. It was first necessary to describe the construction industry - what it was and why it was important. The second area to be explored was a description of different types of construction projects and the actors and procedures involved in developing each project type. With this information as background, a survey questionnaire was developed and distributed to individual

project managers throughout the construction industry. From their responses, a series of descriptions was developed to characterize different types of project managers. Finally, a composite picture of the background, role, and important skills and areas of knowledge was developed for project managers throughout the construction industry.

II. The Construction Industry

The vast majority of people are familiar with the most obvious component of the construction industry - the builder. However, when thinking of the construction industry, one must also consider the other actors in the development of a constructed facility. Each project must also have an owner, a designer, and a user in addition to the builder. Each project manager in the construction industry must define his own function in terms of one or more of these primary roles in project development. Any investigation of the construction industry must delve into each of these areas before it can deal with all facets of a project's life cycle.

The owner's primary responsibilities include conceiving the project, accepting the design and construction of the project if performed by people other than himself, and financing the project. Although the owner may delegate such activities as design and construction to others, he remains the central figure in a project - the ultimate decision maker. The owner may also be responsible for

marketing the facility to users other than himself. The designer, working with the owner, determines what will be built, and, in some cases, how it will be built. In practice, the designer is usually an architect, an engineer, or a combination of both. Occasionally, the owner acts as the designer, although many states require the design to be approved by a professional designer. Builders may be classified as general building contractors, heavy construction contractors, or special trades contractors - such as carpenters, plasterers, plumbers, electricians, etc. The user shares with the owner the responsibility for operating and maintaining the facility.

Construction projects are classified according to their ownership - private or public - and according to their intended use. Table 1.1 lists the type of projects classified by the U. S. Department of Commerce in its monthly Construction Reports.

The U. S. Department of Commerce uses three methods to measure the dollar volume of the construction industry: Construction Receipts, Value-Added, and Value-Put-in-Place. Construction Receipts provide a measure of the payments received by contractors for construction. In 1967 (the most recent year for which detailed data is available) owners paid in excess of $70 billion to contractors for new construction, maintenance, and repairs.

Table 1.1

Project Classification

- Private Construction
  - Residential Buildings
    - New Housing Units
    - Residential Additions and Alterations
    - Nonhousekeeping Residential
  - Nonresidential Buildings
    - Industrial
    - Commercial
    - Religious
    - Educational
    - Hospital and Institutional
    - Miscellaneous Nonresidential
  - Farm Construction - excluding housing
  - Public Utilities
  - All Other Private Construction
- Public Construction
  - State and Local Construction
    - Housing and Redevelopment
    - Educational
    - Hospital
    - Other State and Local Buildings
    - Highways and Streets
    - Conservation and Development
    - Sewer Systems
    - Water Supply Systems
    - Misc. State and Local Construction
  - Federal Construction
    - Residential
    - Industrial
    - Educational
    - Hospitals
    - Other Federal Buildings
    - Military Facilities
    - Highways
    - Conservation and Developement
    - Misc. Federal Construction

Value-added is a measure of the economic input of the construction phase of the development process. "'Value-added' is defined in the 1967 Census of Construction Industries as equal to Total Receipts less payment for constructed work subcontracted to others and payments for materials, components, and supplies."* In 1967, the value added to the economy by construction-oriented activities was $42,322,697,000.

Value-put-in-place is a measurement of the total development cost incurred by the owner. The total value-put-in-place for new construction in 1970 was $94,265,000,000.

The construction industry is significant from a variety of social and economic viewpoints. In 1970, 1,794,000 new homes were built at a cost of over $22 billion. Commercial office space is growing at a rate of 560,000,000 square feet per year. Over 320,000,000square feet of industrial facilities are built each year. The U.S. government finances 9000 miles of new or improved highways each year. Almost 5% of the civilian labor force is employed in construction oriented activities, receiving average earnings higher than any other industrial group in the country. Finally, the average value-put-in-place of new construction represents about 10% of the annual Gross National Product.

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* 1967 Census of Construction Industries, Vol. I, Department of Commerce, Bureau of the Census, (Washington, 1971), p. A-3.

Table 1.2

Project Life Cycle Matrix*

Actor	Conception	Preliminary Analysis	Site Acquisition	Planning and Design	Contract Award	Construction	Marketing and Operation
Owner	Input Market/Needs Analysis Feasibility/ Economic Analysis	Output Needs Statement Schedules Funds Authorization Project Constraints	Location Analysis Engineering Analysis Economic Analysis Site Selection	←	Monitoring Reviewing Approving Award Contract	→	Budgets Promotion
Investor			← Funding →				
Designer				Plans Specifications Contracts Studies	Review Bid/ Proposal	Monitoring Reviewing Approving Changes	Start-up Debugging
Builder						Schedule Build Facility	Guarantee/ Tenant Work
Operator/ User				Design Input			Operating Procedures, Responsibilities

* Adapted from "A Proposed Program in the Management of Capital Facilities Projects," Project Management Committee, M.I.T. Department of Civil Engineering, May 1971.

III. Description of the Development Process

Most constructed facilities can be shown to undergo a fairly well-defined life cycle, beginning with the conception of a project and ending with its eventual demolition or reconstruction. Detailed life cycles of nine major types of constructed facilities are developed in Chapter III of the paper. The following summary will describe a generalized life cycle for all projects, the major actors associated with each phase of the cycle, and the primary responsibilities of each of these actors. Table 1.2 provides a summary of this data.

Conception

The conception of a constructed facility may be defined as the initial envisioning of a project which meets a perceived need. The perceived need may be a very broad or loosely-defined one, such as the need for community housing or the need for a national system of interstate highways. On the other hand, the need may be quite specifically defined, such as the need to add an extra bay to a service station, or the need to rebuild a road to eliminate a dangerous curve. In some cases, the need for a project may even be defined in terms quite unrelated to the eventual physical function of the project - e.g., a need to stimulate the economy (the W.P.A. of the 1930's) or the need to develop an image of national prosperity and development (major hydro-electric projects in developing

nations). In any event, the conception of a project arises out of an analysis of a perceived need for a constructed facility.

There are three major groups of actors who may conceive a project, each group having a slightly different motivation: the owners, the investors, and the user/operators. A fourth group - executive and legislative bodies - incorporate many of the characteristics of each of the former groups. The user/operator usually conceives a project in terms of meeting certain operational requirements - e.g., provide sleeping quarters for two adults and three children, or provide fast and efficient access and egress from one's place of business during the rush hour. The investor, on the other hand, is more likely to conceive a project in terms of its potential return on investment. The owner, in conceiving a project, must act as both the investor and the user. He must conceive a project both in terms of its potential return and in terms of its operational function. A public agency may view a project as providing a necessary service to an area, regardless of its return on investments. Unfortunately, the four groups may conceive the same project in entirely different terms. An example might be a federally subsidized low-cost housing project. Members of the local community may conceive the project in terms of providing better housing at a low cost. An investor's principal interest may be to provide a means for creating a tax shelter. The owner-developer

may view the project as a means of earning a profit. Finally, the public housing agency may view the project as providing part of a quota of much-needed housing in the community. Although these needs are not necessarily incompatible, they do show that a single project may be conceived by a variety of actors to meet quite different needs. For convenience, however, this group of actors in general will be referred to as the owner of a project.

The primary responsibility of the owner is to define the program requirements in terms of the needs to be met by the constructed facility. We must first identify his perceived needs and then evaluate them in order to determine his over-all priorities. We must also determine his return on investment requirements and the basic project timeframe.

Preliminary Analysis

The purpose of preliminary analysis is two-fold: 1) to determine whether to proceed with a project, and 2) to determine the constraints within which the project must develop. During this phase of the life cycle, the needs which lead to conception of the project are re-evaluated to determine their validity and the extent to which the proposed project may meet those needs. In many cases, a detailed market analysis may be undertaken. A financial feasibility study must be made to evaluate the level and source of funding necessary to carry the project from conception to operation,

and to determine the social and economic benefits to be derived from the project. The legal and political ramifications of the project should also be investigated at this time. For a highway project, preliminary analysis may involve a closer evaluation of point-to-point traffic forecasts followed by detailed location studies. For the commercial shopping center developer, preliminary analysis will include a more detailed market analysis and perhaps a search for equity and mortgage capital. For the private home-owner, preliminary analysis must include a thorough appraisal of financial obligations to be met, as well as an evaluation of the attributes the owner is seeking in a new home.

The actors during the preliminary analysis phase of project development are basically the same as those involved in project conception. For this reason, the two phases have been grouped together for the purpose of further analysis in this paper. Even at this time, however, it is not unusual for the owner/developer to hire consultants specializing in planning market analysis, feasibility studies, finance and the like, to add their expertise to that of the client. Typically, the preliminary analysis phase is completed with the determination of the feasibility of the project. If the project is found to be feasible, an additional major actor in the development process will be selected - the designer.

Site Acquisition

The acquisition of a site is usually the first major commitment of an owner to a project. In actuality, acquisition of a site may be made at any time during the project's life prior to construction. In some cases, the owner may acquire a site before conceiving the project. In others, design may be complete before a site is acquired. In most instances, however, it is compatible with the owner's needs. A design is then developed which takes into consideration the advantages and constraints posed by the site.

Three major types of analysis should be performed prior to acquisition of a site. The first is a location analysis which includes in its simplest form a restatement of the market analysis in terms of one or more specific sites. A more elaborate location analysis will identify all of the major constraints imposed upon the project, such as the availability of suitable modes of transportation and utilities and the requirements of existing zoning and building codes. A second evaluation of the site must be an engineering evaluation of the suitability of the site for construction of the proposed project. Finally, an evaluation must be made of the economic feasibility of developing a project at a particular site. Zoning requirements and site preparation costs, for example, may weigh heavily in determining the economic feasibility of one site over another.

Many different actors may aid the owner in arriving at the ultimate decision as to which site to select. Real estate brokers, investors, bankers, lawyers, engineers, and other analysts may all contribute their expertise to assist the owner in arriving at a decision and in negotiating control of a site.

It is also important to recognize the unusual role in which public agencies find themselves during site acquisition proceedings. The right of eminent domain empowers many public agencies to condemn property required for public projects without the approval of the original property owner. While this method of site acquisition is probably most widely used in highway projects, it is becoming an increasingly important tool in urban renewal programs. In fact, the right of eminent domain offers many private developers a means of acquiring large sites in major urban centers.

Planning and Design

The purpose of the planning and design phase is to develop the project as conceived by the owner to the point at which it may be physically constructed. The designer may begin with the needs statement and program requirements developed during the early phases of the project, and attempt to produce solutions to these requirements in the form of a design of a constructed facility. This is often thought of as a two-stage process - conceptual design and detailed design. During conceptual design, solutions may be

developed which define the relationships among various elements of the project. During detailed design, these relationships are further defined into a set of specifications and working drawings for each element of the project.

The designer is usually an architect or engineer chosen by the owner to determine a solution to his particular set of needs. In some cases, the designer may be the owner himself. In others, the designer is a consulting professional chosen by the owner to aid him in developing his concept of the project. In many cases, the designer may employ or request that the owner employ additional specialists to concentrate on particular design problems. The design phase is concluded with the acceptance by the owner of a set of detailed plans and specifications to be used during the construction of the project.

Contract Award

Because of the large sums of money which are involved, and because arrangements are often made for services which may not be rendered until some future date, a legal contract is usually drawn up for design and construction services. The contract itself specifies what obligations are to be met by each of the parties to the agreement. In addition to specifying the services to be provided to the owner, the contract also sets forth the conditions under which the designer or contractor will be paid.

The actors during a contract award for design services are usually the owner, the designer(s), and their legal counsels. In some cases, especially in public construction, a selection committee may be formed to examine and recommend a design agent to the owner. In some cases, design contracts are awarded solely on the basis of reputation or on the basis of a design proposal submitted for review. In other cases, a design contract may be awarded on random or rotating basis from a pre-selected list of designers. Some public agencies use the latter form of selection. In still other cases, the selection is made on the basis of a competitive appraisal of the fees demanded by design agents. Selection on the basis of fee has often been viewed by some as unprofessional, and the practice is currently the subject of considerable public debate.

The award of a contract for construction of the project is often a much more elaborate procedure than that for design services. In addition to the owner and legal counsel, the designer and the interested contractors play major roles. The designer prepares the representations (plans and specifications) from which the project will be bid and constructed. The prospective contractors must review the design documents and usually reply to the owner in the form of a bid or proposal. The owner, in turn, reviews the proposals, often with the aid of the designer. The selection of the contractor is then made by the owner, usually on the basis of the lowest qual-

ified bidder, although, especially in privately developed projects, other criteria may be predominant.

Construction

Construction is the most visible phase of the development process, and usually the phase requiring the largest expenditure of funds. The owner describes the project to the contractor through the contract drawings and specifications. The contractor in turn purchases the materials and constructs the project on the owner's site. The owner inspects the work, using his own staff or hiring inspectors familiar with construction practices and materials. Often, inspection services may be performed under a portion of the design contract. In most cases, periodic inspections are conducted by representatives of various public agencies, particularly the municipal building department. The construction phase is usually completed with the acceptance of the project by the owner and the issuance of a certificate of public agency approval, such as an occupancy permit.

Marketing and Initial Operation

The final phase of the life cycle analyzed here is comprised of the marketing and initial operation of the new facility. In those instances in which the owner is not the sole occupant, or user, an extensive marketing effort may be required to publicize the facility and to find tenants if necessary. Often, marketing a facility

begins soon after the project is conceived. The financial feasibility of a shopping plaza may hinge upon locating a major tenant such as a department store. Similarly, the financing of commercial high-rise towers is often contingent upon the owner showing some portion of the building being already under lease to one or more tenants. To assist this type of marketing, the owner usually calls upon a real estate broker or a marketing specialist within his organization. The broker is able to advise the owner as to current market conditions and maintains a list of prospective clients. The major function of the broker is to bring the buyer and seller together and to assist them in reaching an agreement. Often, he must also mount an extensive publicity program or act as advisor to the owner for such a program.

Almost all facilities require initial start-up programs and the development of operating schedules and budgets. In the case of a nuclear power plant, very detailed procedures must be developed, reviewed, and approved by the owner and public regulatory agencies. An extensive test program may be required before the plant is considered to be operational. Operating budgets will be required for a commercial office building before lease schedules can be adopted. In addition, any facility will require some detailed operating instructions to be developed to inform maintenance and operating personnel about the new physical plant. These instructions are sometimes developed by the design engineers.

IV. Project Managers in the Construction Industry

The Survey

In order to gather information about project managers in the construction industry, a survey was conducted of representatives of many different organizations and project types. To reiterate, the purpose of the survey was to gather information to answer the following questions:

1. Who are the project managers in the construction industry?
2. What is the characteristic of their backgrounds?
3. What is the role of the project manager?
4. What skills and substantive areas of knowledge are important to him in his role as a project manager?

The survey is described in detail in Chapter 4 of this paper. In part A, the participant was asked to describe his educational and professional background. In part B, he was asked to describe in some detail his present position and his role in a recent project. In the final section, the respondent was required to describe what skills and areas of knowledge were important to him as a project manager. Respondents were selected from several directories of developers, designers, constructors, and major owners. Out of a possible 456 respondents, 147 questionnaires were returned completed. An additional 26 questionnaires were returned either unanswered or unopened.

Table 1.3

Distribution of Questionnaire Responses

Organization Type	Number Responses
Owner	18
Developer	16
Architect	6
Engineer	13
Contractor	18
Design/Construct	22
Public Agency	
Highway	29
Building	17
Heavy Construction	6
Construction Manager	2*

* Sample group too small to analyze

Table 1.4

Composite Project Manager

Topic	Response Low	Response Average	Response High
Age (Years)	26	44	62
Years to First Project Management Position	0	14	32
Number Projects Managed	1	9.5	300
Length of Time Act As Manager (Years)	1	2.5	8
Total Project Cost	$100,000	$61.1 M	$750 M

Table 1.5

Educational Background of Project Managers

Degree	Per Cent Respondents
Civil Engineering	50
Other Engineering	33
Architecture	9
Management	4
High School	2
Other	2
Postgraduate*	17

(*included in above categories)

Table 1.6

Composite Project Manager

Continuing Education	Percent Response
Yes	45
No	55
Type Program	
Management	35
Technical	50
Both	15
Entering Career Objective	
Yes	50
No	50
Ultimate Career Objective	
Yes	25
No	75

The completed questionnaires were divided into nine groups, in accordance with the role played by the organization employing the respondent (Table 1.3). Responses were analyzed first by group and then reduced to present a composite picture of all project managers in the construction industry. Details of the method of analysis for each question are presented in Chapter 4.

Composite Description of the Project Manager in the Construction Industry

The survey replies indicate that there is no one background which is characteristic of all project managers. The average age of the respondents was 44 years, but the ages ranged from a low of 26 years to a high of 62 years (Table 1.4). The vast majority of the respondents were graduate engineers; 50% held degrees in civil engineering (Table 1.5). Only 2% had not received at least a two-year college degree, and 17% held post-graduate degrees. Although only 4% held management degrees, over 25% of the respondents had participated in continuing education courses within the past four years which were managerial in nature (Table 1.6).

The project manager generally enters the construction industry as a design engineer or as a member of a construction field staff. Future positions emphasize development of a technical expertise, management of the technical details of a project, and, finally, management of the business details of the project. The average

project manager first assumes total responsibility for a project 14 years after receiving his undergraduate degree (Table 1.4). Again, a wide variation of responses was received, ranging from a maximum of 32 years down to one respondent who held a project management position before leaving college. In general, there was a definite progression of responsibility from technical assistant to technical leader, to managerial assistant, to managerial leader. As would be expected, many respondents stated that their success at handling smaller jobs would usually lead to progressively more responsible positions and more complex projects. The majority of the respondents had ultimate career objectives other than project management, however. Many of these stated they desired general management positions within their present organization. Others stated they would like to manage their own development, design, or construction firm.

Although job descriptions for project managers in most organizations have specific professional and educational requirements, some are quite general. Most organizations required a technical degree from a two- or four- year college. Most of the respondents cited a record of progressive responsibility. Many positions - particularly those with public agencies - required professional registration as an architect or engineer.

The role of the project manager can be characterized in several ways (Table 1.4). Project managers commonly exist for all

Table 1.7

Project Data

Organization Type	Average Number Projects Managed	Average Time Act As Manager	Average Total Project Cost
Owner	14	2.3yr.	$60M
Developer	2.5	2.0	28
Architect	3	3.0	20
Engineer	3.3	2.1	35
Contractor	1.7	2.1	35
Design/Construct	1.8	2.7	130
Public Agency			
Highway	30	1.6	11
Building	26	2.6	98
Heavy Construction	3.8	4.2	84

Table 1.8

Most Frequently Cited Activities

Conception and Preliminary Analysis

1. Determine project staging/timing.
2. Prepare preliminary budget estimates.
3. Determine technical feasibility.

Site Acquisition

1. Obtain necessary public agency approval of desired site(s).
2. Perform location analysis.
3. Select site.

Planning and Design

1. Prepare project cost estimates.
2. Review and/or approve design documents.
3. Coordinate design with activities outside organization.
4. Establish design schedule.
5. Coordinate design activities within organization.
6. Define design program requirements.
7. Assemble design team.

Contract Award

1. Evaluate bid/proposal.
2. Negotiate bid/proposal.

Construction

1. Negotiate change orders.
2. Monitor construction costs.
3. Inspect construction periodicly.
4. Estimate percent completion.
5. Accept completed work.
6. Establish inspection/quality control system.
7. Approve application for progress payment.
8. Schedule construction.
9. Determine construction methods and procedures.

Marketing and Initial Operation

1. Prepare operating and maintenance schedules.
2. Conduct trial and debugging operations.
3. Prepare operating budget.

types of projects and for each of three major actors in project development: owner, designer, and constructor. Project managers are usually associated with large projects; the respondents were asked to describe a current or recently completed project and, on average, its development cost was $61 million. Although many respondents managed only one or two projects at one time (median - 3.8), the over-all average was 9.5 projects. Project managers for private owners, public highway agencies, and public building agencies managed considerably more projects than average, implying that these respondents were administrative managers, rather than project managers in the strictest sense of the term. The respondents acted as manager for a project for an average of 2.5 years.

A detailed analysis of the role played by each of the nine groups was developed and is presented in Chapter 4. For the purpose of this composite description of the project manager, however, it is more useful to examine the activities most frequently cited by all of the respondents (Table 1.8).

During the conception and preliminary analysis phase, the project manager is directly involved in determining the staging and timing of a project and in preparing preliminary budget estimates. To a lesser degree, he is also often involved in the conception and definition of the project. He is not usually involved directly in determining how the project is to be financed.

Few of the respondents participated in the site acquisition phase. Site selection appeared to be primarily the role of the owner or the developer, although many of the respondents appeared to be involved in location analysis.

The respondents acted as managers of the planning and design phases, presumably leaving detailed design work to staff and consultants. Most of the respondents participated in the preparation of project cost estimates and in the review and approval of design documents.

The two most frequently cited activities during the contract award phase were evaluating a bid or proposal and negotiating the contract. Each received a response from approximately 50% of the respondents.

The project manager acts primarily as a business manager during construction. The most frequently cited activities during this phase include the negotiation of change orders and the monitoring of construction costs. The responses show that the project managers representing the owner and the designer are also frequently involved in these construction tasks.

Few of the project managers were involved in the activities associated with marketing and the initial operation of the facility. The most frequently cited activities were the preparation of operation and maintenance schedules, the conduct of trial and debugging

Table 1.9

Important Skills and Areas of Knowledge

Rank	Skill or Area of Knowledge
1	Project planning and analysis
2	Understanding overall organization and operation of construction industry
3	Interpersonal relations
4	Methods of time and cost control
5	Contracts
6	Technical proficiency
7	Financial management
8	Management information systems
9	Labor relations
10	Other legal factors
11	Marketing

operations, and the preparation of the operating budget.

Table 1.9 shows the relative importance assigned by the project managers to a list of requisite skills or areas of knowledge. The most important area to a project manager is project planning and analysis. This area requires the ability to determine project staging, to perform the location analysis, to define the design program requirements, to establish inspection and quality control systems, and to prepare operating and maintenance schedules - to name a few activities. Understanding the over-all organization and operation was rated the second most important area. This knowledge is useful to the manager who is attempting to define a project, seeking public agency approval of sites or design documents, or coordinating design and construction activities. Comments were frequently noted relating to the third-ranking topic - interpersonal relations. Many of the managers felt that their most important task was to work with other people to develop the project. Methods of time and cost control were ranked fourth of the eleven areas which were listed in the questionnaire. Some of the lower-ranked areas apparently implied activities which are outside the normal scope of the project manager and more closely related to the work of staff specialists who might be employed on the project.

V. Summary

The project manager in the construction industry, whether he is representing the owner, designer, or constructor of a facility, acts as the coordinator and overseer of the business and technical functions of project development. He is relatively young, but has a broad background in construction and has considerable on-the-job experience. Typically, he manages large projects in the multi-million dollar category. His role can be summarized as encompassing four major functions: definition of the project, analysis of the feasibility of the project and of the many solutions to problems which will be encountered during development, determination and evaluation of cost and time requirements, and coordination of the many actors who participate in the development process. Finally, his most important attributes are his knowledge of the over-all construction industry, his ability to analyze and plan his tasks in the development process, and his ability to accomplish his goals through the efforts of other people.

CHAPTER 2

DESCRIPTION OF THE CONSTRUCTION INDUSTRY

I. Introduction

Construction, as used in this paper, is defined as "the erection, maintenance, and repair (including replacement of integral parts) of immobile structures, together with service facilities which when installed become integral parts of structures and are essential to their use for any general purpose."* The construction industry may be seen to include a broad spectrum of talents, including in its ranks the owners, designers, builders, and users of capital facilities. This description will focus attention upon the major components of the industry in terms of actors and project types, upon measuring the dollar volume of the industry, and upon its importance as a social and economic force.

II. Actors in the Construction Industry

The actors in the construction industry may be classified according to the role they perform. Four major roles may be defined as being associated with all projects: ownership, design, construc-

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* Construction Statistics 1915-1964, A Supplement to Construction Review, U.S. Department of Commerce/Business and Defense Services Administration (Washington, 1966), p. 75.

tion, and utilization. All four roles may be performed by one individual or organization, or separate organizations may evolve which specialize in one or more of these tasks. The owner is responsible for conceiving the project, for accepting the design and construction if performed by others, and for financing the project. The owner, like the other actors, may be an individual, group of individuals, a company, a corporation, or a public agency representing the federal, state, or local government. In addition, the owner may be responsible for marketing the completed facility to users other than himself. Owners, whose business it is to design and construct facilities for users other than themselves, may be known as developers. The designer, working with the owner, determines what will be built and, in some cases, how it will be built. He usually develops the working drawings and the technical contract specifications. In practice, the designer is usually an architect, an engineer, or a combination of both. The contractor, who is responsible for building the facility for the owner, may be a general building contractor, a heavy construction contractor, or a combination of one or more special trades contractors, such as plasterers, plumbers, electricians, etc. Finally, each facility must have a user. The user shares with the owner the responsibility for maintenance, repair, and modification of the facility.

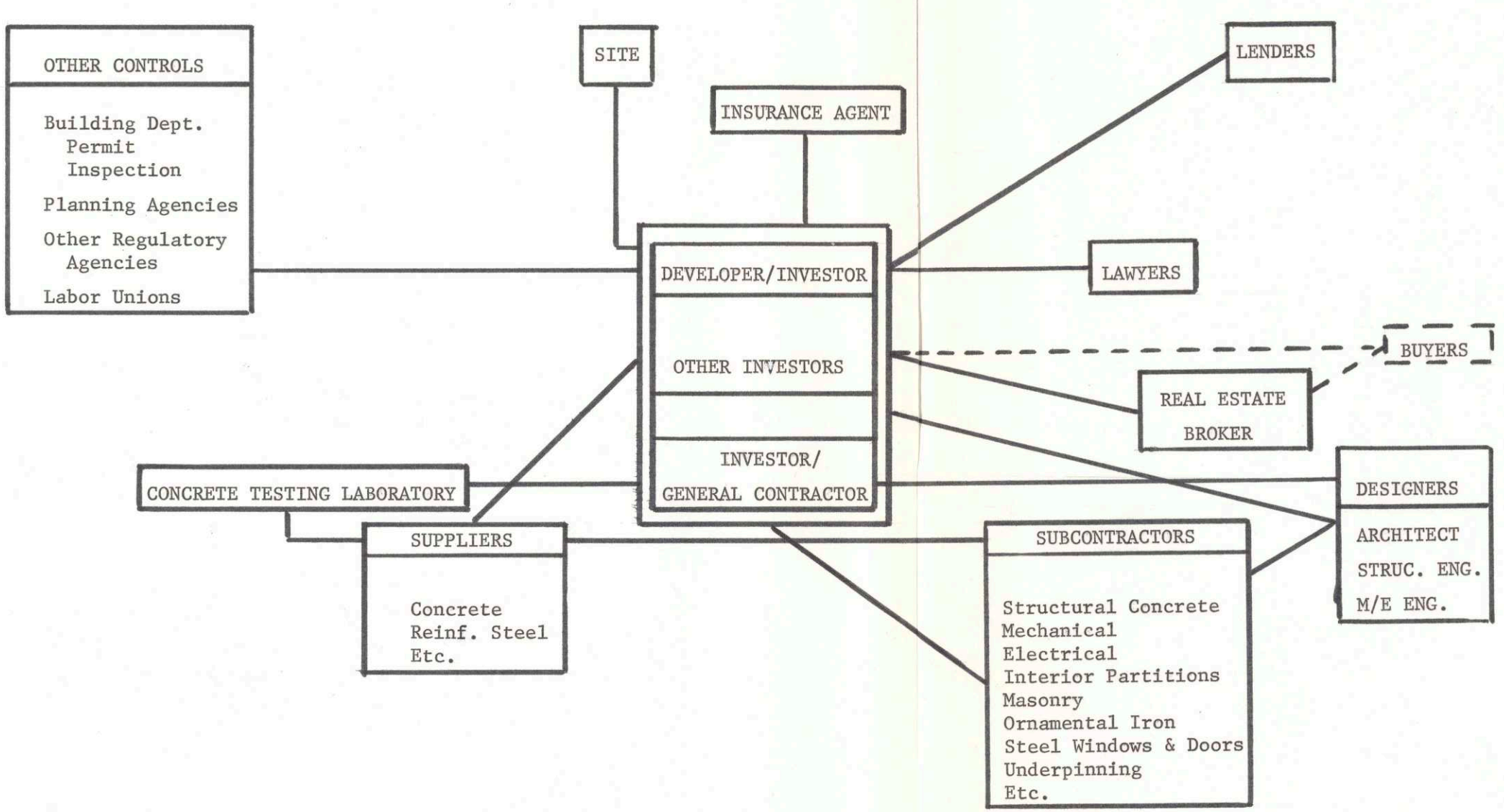
Depending upon the complexity of the project, each of the major

actors may have many other actors associated with him, each specializing in some area of the development process. The owner may have several different analysts advising him on such topics as financing sources (bankers, public agency officials, and investors), zoning and contractual agreements (lawyers), and the marketability of the facility or the goods and services which will be available at the facility (market, demand, and location analysts, real estate brokers). In addition, he may employ consultants to advise him how best to manage the design and construction of his project (construction or project managers). The designer may employ, or ask the owner to employ, technical consultants to advise on specialized design problems. The designer may offer the owner the services of an inspector or engineer who acts as the owner's on-site representative and monitors the work performed by the contractor. The contractor, in turn, may employ technical experts to assist him in the preparation of bids and to advise him in planning how he will construct the project. Also working with the contractor will be his suppliers and subcontractors, each bringing his own technical expertise to bear on the construction process. The user may employ his own group of specialists to design the interior finishes or the arrangement of furniture and equipment to meet his specific user needs, or to plan future modifications to an existing facility.

In addition to the four major actors who may be considered to

Figure 2.1*

Actors in a Typical High Rise Condominium Development



* Adapted from "A Proposed Program in The Management of Capital Facilities Projects," Project Management Committee, M.I.T. Department of Civil Engineering, May 1971.

have a direct influence upon the production of the completed facility, there are two additional groups of actors which contribute indirectly: governmental regulatory agencies and labor unions. Quite apart from the many public agencies that act as owners, designers, and users of constructed facilities, government regulatory agencies have a profound effect upon the conduct of business in the construction industry. These agencies play an important role in determining what actors will be involved in a particular project, where the project will be located, and what design characteristics will be incorporated. In addition to those agencies which underwrite financing (Federal Housing Administration, Small Business Administration), and those which issue building and occupancy permits (Building Departments), sanitation and well permits (Board of Health), and operating permits (Environmental Pollution Agency, Utility Commissions), there exist public inspectors who periodically monitor construction methods, materials, workmanship, labor conditions, and safety practices. Labor unions must also be considered to have an indirect effect on the construction process. In a major portion of new construction, union contracts between the labor force and the contractor outline the jobs each trade may accomplish on a project and wage scales, working conditions, and construction methods that will be employed.

As an example, Figure 2.1 depicts the actors who may be involved in a typical high-rise condominium complex and some of the relation-

ships which may exist among these actors. As can be seen from this diagram, the developer and the general contractor, in addition to their usual roles of planning and constructing the project, also act as investors/owners of the project, implying that each provides part of the equity capital needed to finance the project, and each will share in the profits realized from the scale of the condominiums. Otherwise, the relationships shown are similar to those which would exist for any privately financed building project.

III. Types of Construction Projects

Just as the actors in the construction industry can be classified according to the service they provide, construction projects may be classified according to their ownership, construction characteristics, and use. All projects are first classified according to whether they are publically or privately owned. Included in public construction are all projects owned by federal, state, or local governments, public authorities, and special districts. All other construction, including that of "public utilities," is classified as private. It should be emphasized that this distinction applies only to ownership and not to the source of financing. Thus there may be projects which are financed by the government - through the Federal Housing Administration, for example - that are considered private construction. Further classification is made on the basis of whether a project is considered to be new construction (including major addi-

Table 2.1*

Construction Receipts by Type of Construction and Industry Groups, for Establishments with Payroll: 1967

(Dollar figures in thousands.)

Item	Construction Industries Total	Total	Contract Construction Industries: General Building Contractors	Heavy Construction Contractors	Special Trade Contractors	Subdividers, Developers And Operative Builders
Total Number of Establishments	368,771	350,133	95,049	33,995	221,039	18,638
Construction Receipts	92,588,002	87,939,112	32,871,764	23,551,544	31,515,804	4,648,890
Payments for Construction Work Subcontracted to Others	23,069,834	20,846,733	15,326,415	3,541,045	1,979,213	2,223,101
Net Construction Receipts	69,520,058	67,093,865	17,545,810	20,010,602	29,537,463	2,426,193
Distribution by Type of Construction:						
Building Construction, Total	63,822,045	59,610,075	31,430,538	1,014,564	27,164,973	4,211,970
Single-Family Houses	18,469,472	14,673,880	7,718,529	57,226	6,898,125	3,795,592
Multifamily Residential Buildings	5,087,972	4,805,883	2,046,367	36,986	2,722,530	282,089
Other Residential Buildings	1,940,554	1,925,388	1,007,869	20,530	896,989	15,166
Industrial Buildings and Warehouses	14,254,061	14,204,179	7,215,553	583,127	6,405,499	49,882
Office and Bank Buildings	5,367,546	5,352,829	2,818,409	92,356	2,442,064	14,717
Stores, Restaurants, Public Garages, and Auto Service Stations	3,955,747	3,932,801	2,161,108	39,409	1,732,284	22,946
Religious Buildings	1,885,685	1,880,979	1,053,665	13,963	813,371	4,706
Educational Buildings	8,056,925	8,040,397	4,694,007	92,751	3,253,639	16,528
Hospital and Institutional Buildings	3,605,607	3,601,385	1,961,681	45,517	1,594,187	4,222
Amusement, Social, and Recreational Buildings	817,173	811,762	487,063	22,698	301,996	5,411
Farm Buildings	162,557	161,896	121,763	3,097	37,036	661
Other Nonresidential Buildings	218,746	218,696	144,539	6,904	67,253	-

* 1967 Census of Construction Industries, Vol. 1, Department of Commerce, Bureau of the Census (Washington, 1971), p.B-12.

Table 2.1 (cont.)

Item	Construction Industries Total	Contract Construction Industries Total	General Building Contractors	Heavy Construction Contractors	Special Trade Contractors	Subdividers, Developers And Operative Builders
Nonbuilding Construction, Total	23,990,281	23,912,643	677,348	21,845,866	1,389,429	77,638
Highways and Streets	7,939,100	7,908,681	127,118	7,628,215	153,348	30,419
Outdoor Swimming Pools	198,477	-	-	184,313	8,402	-
Parking Lot Construction	116,229	119,229	2,333	105,371	8,525	-
Fence Construction	100,498	-	-	100,257	-	-
Bridges, Tunnels, and Elevated Highways	2,041,352	2,041,325	93,935	1,874,965	72,425	27
Dam and Reservoir Construction	782,024	781,407	16,426	735,691	29,290	617
Marine Construction	472,990	472,279	10,585	454,347	7,347	711
Harbor and Port Facility Construction	245,066	-	24,221	210,805	-	-
Conservation and Development Construction	675,813	671,507	10,682	611,228	49,597	4,306
Power and Communication Transmission Lines, Towers, and Related Facilities	1,854,530	1,852,450	85,166	1,672,487	94,797	-
Sewers, Water Mains, and Related Facilities	3.017,532	2,990,800	106,608	2,432,137	452,055	26,732
Pipeline Construction	999,434	-	-	948,709	41,351	-
Mass Transit Construction	273,818	273,818	10,624	246,515	16,679	-
Heavy Industrial Facilities	4,329,021	4,329,021	104,673	3,954,760	269,588	-
Other Heavy Construction (Military and Space Facilities)	549,986	549,386	48,287	428,134	73,568	-
Other Nonbuilding Construction	394,411	382,551	22,000	257,935	102,616	11,860
Construction Work Not Specified By Kind	4,775,676	4,416,394	763,878	691,114	2,961,402	359,282

tions or alterations) or maintenance and repairs, and whether or not the project involves construction of a building (building construction vs. non-building construction). Different systems have been developed for classifying projects according to their intended use. Two such systems are those used by the Bureau of the Census in the 1967 Census of Construction Industries and their monthly publication, Construction Review, a compilation of statistics dealing with the construction industry. Descriptions of both systems are included in Appendix A.

IV. Measuring the Dollar Volume of the Construction Industry

The U.S. Department of Commerce uses three methods to measure the volume of the construction industry and of any project in the industry: Construction Receipts, Value Added, and Value-Put-In-Place. Construction Receipts provide a measure of the payments received by contractors for construction. Table 2.1 shows the construction receipts which different types of contractors received in 1967. Receipts can be defined by two different methods. Total Construction Receipts provide a measure of all payments made to contractors. However, because portions of a project may be subcontracted to speciality contractors, Total Construction Receipts overstates the amount spent by owners for construction. Payments for work which is subcontracted are counted twice - once when received by the prime contractor and again when received by the subcontractor. A second method has been

established - Net Construction Receipts - which is defined as Total Construction Receipts less Payments to Subcontractors. Net Construction Receipts, therefore, is a measure of the payments made by the owners for construction. Table 2.1 shows that the Net Construction Receipts for the estimated 368,771 establishments with payroll (i.e., employees other than the owner or proprietor) was $69,520,058,000. Although no net figures are available, Total Construction Receipts for establishments without payroll amounted to $3,337,947,000. Therefore, construction contractors received payment in excess of $70 billion for new construction, maintenance, and repairs in 1967. Value Added is a measurement which represents the economic input of the construction phase of the developmental process. " 'Value Added' is defined in the 1967 Census of Construction Industries as equal to Total Receipts less payments for constructed work subcontracted to others and payments for materials, components, and supplies."* In 1967 the value added to the economy by the construction industries was $42,322,697,000 (Table 2.2).

Table 2.2**
Value Added by the Construction Industries - 1967

Type of Builder	
General Building Contractors	$ 9,741,519,000
Heavy Construction Contractors	12,698,387,000
Special Trade Contractors	18,514,537,000
Subdividers, Developers, Operative Builders	1,368,254,000
Construction Industries, Total	$42,322,697,000

* 1967 Census of Construction Industries, Vol. 1, Department of Commerce, Bureau of the Census (Washington, 1971), p. A-3.
** Ibid., p. 1B-2.

Table 2.3*

Table 1. **ANNUAL VALUE OF NEW CONSTRUCTION PUT IN PLACE IN THE UNITED STATES: 1958 TO 1970 IN CURRENT DOLLARS; 1969 AND 1970 IN 1967 DOLLARS**

Type of construction	In current dollars							
	1958	1959	1960	1961	1962	1963	1964	1965
Total new construction	50,153	55,305	54,632	56,292	59,965	64,563	67,413	73,412
Private construction	34,696	39,235	38,769	39,144	42,096	45,206	47,030	51,350
Residential buildings (including farm)	[1]19,789	[1]24,251	22,975	23,107	25,150	27,874	28,010	27,934
New housing units	15,445	19,233	17,279	17,074	19,443	21,735	21,786	21,712
1 unit structures	(NA)	(NA)	14,648	13,758	14,601	15,297	15,337	15,705
2 or more unit structures	(NA)	(NA)	2,631	3,316	4,842	6,438	6,449	6,007
Additions and alterations	[1]3,711	[1]4,253	4,831	4,973	4,484	4,798	(NA)	4,736
Nonhousekeeping	633	765	865	1,060	1,223	1,341	1,457	1,486
Nonresidential buildings	8,675	8,859	10,149	10,734	11,617	11,646	12,955	16,509
Farm (other than residential)	[2]1,355	[2]1,397	743	718	722	709	696	703
Public utilities	4,688	4,521	4,621	4,335	4,330	4,667	5,031	5,788
Telephone and telegraph	904	951	1,088	980	996	1,128	1,314	1,463
Other public utilities	3,784	3,570	3,533	3,355	3,334	3,539	3,717	4,325
Railroad	272	218	270	213	201	253	267	310
Electric light and power	2,291	2,007	2,026	1,886	1,899	2,066	2,211	2,589
Gas	1,065	1,214	1,105	1,147	1,031	948	1,073	1,304
Petroleum pipelines	156	131	132	109	203	272	166	122
All other private construction	189	207	281	250	277	310	338	416
Public construction	15,457	16,070	15,863	17,148	17,869	19,357	20,383	22,062
Buildings	5,499	5,476	5,511	6,011	6,092	6,534	7,177	7,893
Housing and redevelopment	846	962	716	842	938	531	567	603
Industrial	408	368	407	472	422	440	403	368
Educational	2,875	2,656	2,818	3,052	2,984	3,477	3,790	4,284
Hospital	390	428	401	369	397	426	469	520
Other public buildings	980	1,062	1,169	1,276	1,351	1,660	1,948	2,118
Highways and streets	5,545	5,761	5,437	5,854	6,365	7,084	7,133	7,550
Military facilities	1,402	1,465	1,366	1,371	1,266	1,179	910	830
Conservation and development	1,019	1,121	1,175	1,384	1,523	1,694	1,750	2,019
Other public construction	1,992	2,247	2,374	2,528	2,623	2,866	3,413	3,770
Sewer systems	836	906	882	914	1,072	947	1,325	1,195
Water supply facilities	551	561	605	667	682	882	956	1,266
Miscellaneous public construction	605	780	887	947	869	1,037	1,132	1,309

* Construction Reports - Series C30-70S - Value of New Construction Put In Place, 1958-1970, Department of Commerce (Washington, 1971), pp. 4-5.

Table 1. **ANNUAL VALUE OF NEW CONSTRUCTION PUT IN PLACE IN THE UNITED STATES: 1958 TO 1970 IN CURRENT DOLLARS; 1969 AND 1970 IN 1967 DOLLARS**—Continued

Type of construction	In current dollars					In 1967 dollars	
	1966	1967	1968	1969	1970	1969	1970
Total new construction	76,002	77,503	86,626	93,345	94,265	81,632	77,350
Private construction	51,995	51,967	59,021	65,384	66,147	57,208	55,068
Residential buildings (including farm [2]	25,715	25,568	30,565	33,200	31,748	29,040	27,332
New housing units	19,352	18,985	24,030	25,941	24,156	22,689	20,798
1 unit structures	14,109	14,261	16,827	16,413	14,824	14,356	12,765
2 or more unit structures	5,243	4,724	7,203	9,528	9,332	8,333	8,033
Additions and alterations	4,941	5,317	5,297	5,882	6,234	5,145	5,367
Nonhousekeeping	1,422	1,266	1,238	1,377	1,358	1,206	1,167
Nonresidential buildings	18,279	17,589	18,164	21,155	21,417	18,282	17,013
Farm (other than residential)	714	753	750	784	P 837	680	P 709
Public utilities	6,803	7,603	8,969	9,504	P 11,199	8,574	P 9,281
Telephone and telegraph	1,609	1,638	1,704	2,172	2,952	1,935	2,359
Other public utilities	5,194	5,965	7,265	7,332	P 8,247	6,639	P 6,922
Railroad	378	327	413	453	P 348	406	P 285
Electric light and power	3,060	3,777	4,452	4,764	P 5,974	4,324	P 5,010
Gas	1,614	1,549	2,043	1,884	P 1,669	1,700	P 1,414
Petroleum pipelines	142	312	357	231	(NA)	209	(NA)
All other private construction	484	454	573	741	946	632	733
Public construction	24,007	25,536	27,605	27,963	28,118	24,424	22,282
Buildings	8,920	9,982	10,439	11,230	10,657	9,733	8,521
Housing and redevelopment	655	709	746	1,047	1,107	918	954
Industrial	389	408	519	518	500	449	394
Educational	5,333	5,988	6,061	5,868	5,818	5,080	4,412
Hospital	511	636	698	804	837	695	676
Other public buildings	2,052	2,240	2,415	2,993	2,595	2,591	2,085
Highways and streets	8,405	8,591	9,321	9,252	9,986	8,220	7,881
Military facilities	727	695	808	879	719	769	569
Conservation and development	2,194	2,124	1,973	1,780	1,922	1,524	1,494
Other public construction	3,761	4,144	5,064	4,822	4,834	4,178	3,817
Sewer systems	1,300	1,058	1,551	1,344	1,544	1,155	1,201
Water supply facilities	1,066	1,270	1,514	1,338	1,094	1,148	857
Miscellaneous public construction	1,395	1,816	1,999	2,142	2,196	1,875	1,759

NA Not available. P Preliminary.
[1] Excludes farm.
[2] Includes farm housing units.

Table 2.4

Value-Put-In-Place as a Percentage of Total New Construction, By Project Type

1915-1970

		1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1962	1964	1966	1968	1970
Total New Construction	($)	3262	6749	11439	8741	4232	8682	5809	33575	46519	54632	59965	67413	76002	86626	94265
Private	($)	2543	5397	9301	5883	1999	5054	3411	26709	34804	38769	42096	47030	51995	59021	66147
	(%)	77.9	79.7	81.3	67.3	47.2	58.2	58.7	79.5	74.8	70.9	70.2	69.7	68.4	68.1	70.1
Residential		37.4	29.8	48.2	23.7	23.8	34.3	21.9	53.9	47.0	42.0	41.9	41.5	33.8	35.2	33.6
Industrial		6.0	16.2	4.4	6.0	3.7	5.0	11.0	3.1	5.1	5.2	4.7	5.2	-	6.9	6.9
Commercial		-	9.2	8.1	10.1	4.9	3.9	3.4	4.1	6.8	7.6	8.5	8.0	-	8.9	10.3
Religious		-	0.8	1.4	1.5	0.6	0.6	0.4	1.2	1.5	1.8	1.7	1.4	-	1.2	0.9
Educational		-	0.3	0.9	1.3	0.4	0.5	0.5	0.8	1.0	1.0	1.1	1.0	-	1.2	0.9
Hospital & Institutional		-	0.4	0.6	1.2	0.2	0.3	0.6	1.0	0.7	1.1	1.6	1.9	-	1.8	2.6
Misc. Non-Res. Buildings		-	1.9	2.2	2.2	1.1	1.0	1.3	1.1	0.8	1.7	1.5	1.5	-	0.7	0.8
Total Public Utilities		16.3	11.3	11.3	17.4	8.5	8.8	14.2	9.0	8.0	8.4	7.2	7.4	8.9	10.3	11.8
Telephone & Telegraph		1.3	1.8	1.8	3.8	1.2	1.4	2.0	1.3	1.7	1.9	1.6	1.9	2.1	1.9	3.1
Other Private		2.0	1.2	0.9	0.9	0.6	0.3	0.3	0.3	0.4	0.5	0.4	0.5	0.6	0.6	1.0
Public	($)	719	1352	2138	2858	2233	3628	2398	6866	11715	15863	17869	20383	24007	27605	28118
	(%)	22.1	20.0	18.6	32.6	52.7	41.7	41.2	20.4	25.1	29.0	29.7	30.2	31.5	31.8	29.8
Housing & Redevelopment		-	-	-	-	0.2	2.3	1.3	1.0	0.5	1.3	1.5	0.8	0.8	0.8	1.1
Industrial		-	-	-	-	0.	1.8	12.9	0.6	1.5	0.7	0.7	0.5	0.4	0.5	0.5
Educational		-	2.8	3.4	4.1	3.6	1.7	1.0	3.3	5.2	5.1	4.9	5.6	7.0	6.9	5.9
Hospital & Institutional		-	0.4	0.5	1.3	0.8	0.6	1.4	1.4	0.6	0.7	0.6	0.6	0.6	0.8	0.8
Other Buildings		-	0.8	0.8	2.0	3.1	2.7	0.6	1.5	1.5	2.1	2.2	2.8	2.6	2.7	2.7
Highways & Streets		9.2	9.7	9.4	17.3	19.9	14.9	6.8	6.3	8.2	9.9	10.6	10.5	11.0	10.7	10.5
Military Facilities		0.5	2.3	0.	0.3	0.8	4.4	11.8	0.5	2.7	2.5	2.1	1.3	0.9	0.9	0.7
Conservation & Development		1.1	0.8	0.6	1.5	16.5	6.0	2.2	2.8	1.5	2.1	2.5	2.5	2.8	2.2	2.0
Sewer		1.5	0.9	1.1	1.6	2.3	2.1	0.6	1.1	1.3	1.6	1.7	1.9	1.7	1.7	1.6
Water Supply		1.6	1.2	1.2	2.2	1.7	1.7	1.0	0.8	1.0	1.1	1.1	1.4	1.4	1.7	1.1
Misc. Public		1.2	0.5	1.0	1.8	3.3	2.9	1.0	0.5	0.7	1.6	1.4	1.6	1.8	2.3	2.3

Figures for 1915-1955 based on U. S. Department of Commerce - Construction Statistics 1915-1964, A Supplement to Construction Review
Figures for 1956-1970 based on U. S. Department of Commerce - Construction Reports, Series C30-70S, Value of New Construction Put in Place, 1958-1970.

Value-put-in-place is a measurement of the total development cost incurred by the owner, including his overhead expenses, financing costs, design costs, and payments to contractors. Monthly estimates of value-put-in-place are developed by the Department of Commerce for different project types. Table 2.3 is a summary of the annual value-put-in-place for new construction during each of the years 1958-1970. Table 2.4 shows, for selected years, the annual value-put-in-place for each project type expressed as a percentage of the total value-put-in-place for new construction. From these tables it is apparent that residential construction is by far the most significant project type, followed by highways and streets, public utilities, commercial, industrial, and educational projects. Table 2.5 summarizes the average percent of the annual value-put-in-place for the six most important project categories.

Table 2.5
Most Important Project Categories

Project Category (combines public and private construction)	Average % of Value-Put-In-Place
Residential	37.9
Highways and Streets	10.9
Public Utilities	9.7
Commercial	9.4
Industrial	7.6
Educational	5.7

V. Significance of the Construction Industry

The significance of the construction industry can be viewed from a variety of social and economic viewpoints. The $22 billion

Table 2.6*

Average Earnings and Hours Worked Per Week in Industry

Industry	1971 Earnings	1971 Hours Worked
All Manufacturing	$141.65	39.9
Primary Metal Industries	173.46	41.3
Iron and Steel Foundries	162.41	40.5
Nonferrous Foundries	148.85	39.8
Fabricated Metal Products	156.26	40.6
Hand Tools	137.66	39.9
Hardware	147.97	40.1
Structural Metal Products	157.59	40.8
Electrical Machinery	139.65	39.9
Machinery, except Electrical	159.98	40.4
Transportation Equipment	180.67	40.6
Automobiles	203.84	41.6
Nondurable Goods	127.01	39.2
Telephone	133.56	51.4
Gas and Electric Utilities	182.07	41.1
Wholesale Trade	115.35	39.1
Retail Trade	143.78	39.5
Private Building Construction	206.46	37.0

* Information Please Almanac, Atlas and Yearbook, Ed. Dan Golenpaul, (New York, 1971), pp. 122-3.

spent on new private housing in 1970 represents 1,794,000 new homes for American families. Commercial office space is being added at a rate of 560,000,000 square feet per year. Industrial facilities are being expanded at a rate of 320,000,000 square feet per year. The United States Government, through the Bureau of Public Roads, financed the construction or improvement of over 9,000 miles of interstate, primary, secondary, and urban highways. The annual labor payroll of over $24 billion represents jobs for 3.4 million employees of contractors, subdividers, developers, and operative builders, almost 5% of the civilian labor force. The average earnings of those employed in private building construction are the highest for any industrial group in the country (Table 2.6). In addition to the construction labor force, the industry provides employment for some 31,000 architects, 46,000 surveyors, and as many as 66,000 civil engineers. To these ranks must be added the thousands of mechanical, electrical, and industrial designers; owners; developers; investors; and governmental workers whose employment is derived from construction-related activities.

The economic significance of the construction industry can hardly be overemphasized. As shown in Figures 2.2 and 2.3, the construction industry is a major factor in the national economy. The $94 billion value-put-in-place of new construction in 1970 represents almost 10% of the Gross National Product.

Figure 2.2*

Gross National Product

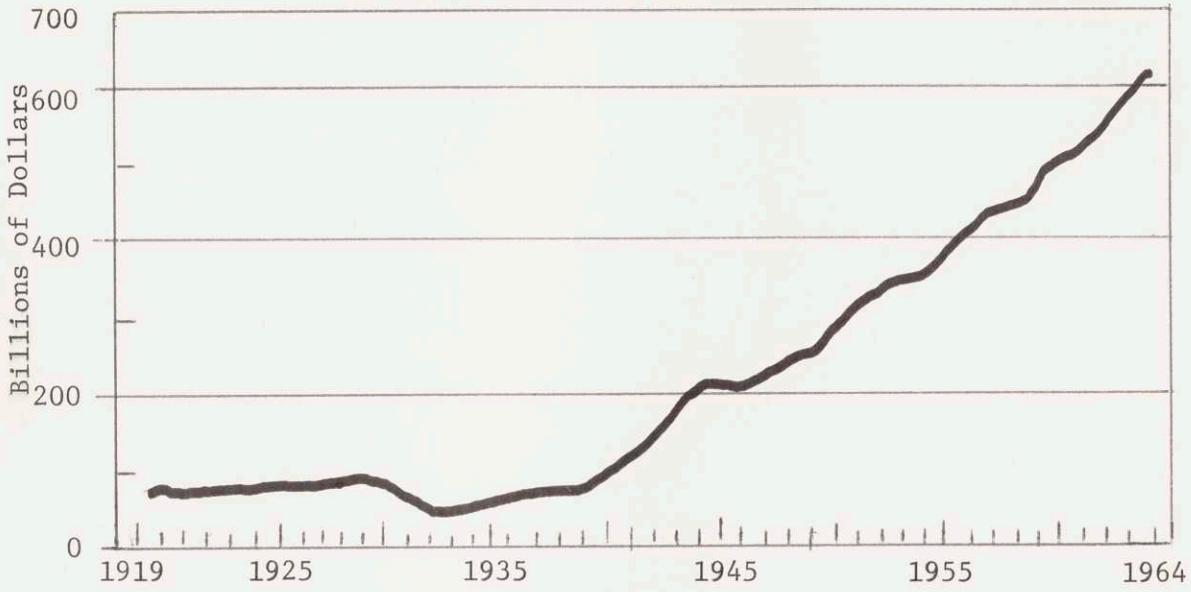
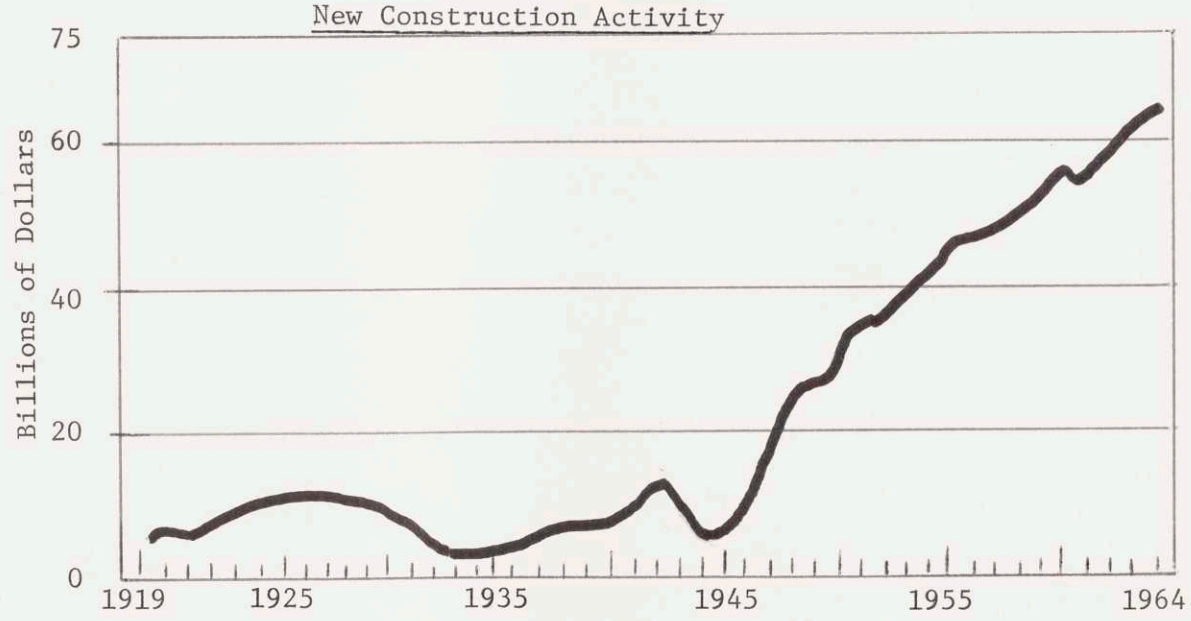


Figure 2.3*

New Construction Activity



* Construction Statistics, 1915-1964, S upplement to Construction Review,(Washington, 1966) p. 3.

CHAPTER 3

DESCRIPTION OF THE DEVELOPMENT PROCESS

I. Introduction

In this chapter the development process for six different project types will be described. These descriptions will include residential, industrial, commercial, highway, and educational projects.

II. The Development of Residential Buildings

Residential construction is the single most important project type in terms of value-put-in-place. Five categories of residential construction can be described as shown in Table 3.1. In the following sections, two of these - private single-family and private multi-family projects - will be described in some detail.

Table 3.1*
Value of New Residential Construction - 1970

Type of Dwelling	Value-Put-In-Place
Private Single-Family Dwellings	$14,824,000,000
Private Multi-Family Dwellings	9,332,000,000
Private Additions and Alterations to Dwellings	6,234,000,000
Private Non-Housekeeping Dwellings (dormitories, hotels, etc.)	1,358,000,000
Public Housing and Redevelopment	1,107,000,000
Value-Put-In-Place, Total	$32,855,000,000

* Construction Reports - Series C30-70S, Value of New Construction Put in Place; 1958-1970, U.S. Department of Commerce (Washington, 1971), p.4.

A. Single-Family Dwellings

Private single-family dwellings account for almost 15% of the value-put-in-place for all new construction. In terms of monetary value, therefore, construction of single-family homes is the most significant sector of the entire construction industry. Several different types of projects can be defined. The two most important categories are those projects which are developed for later sale (i.e., speculative housing), and those projects which are build for the owner on his land (custom-built housing). The latter category includes homes built for the owner by a general contractor, homes in which the owner acts as his own general contractor, and homes in which the owner undertakes part or all of the actual construction himself. Table 3.2 shows the relative significance of each of these types of projects.

Table 3.2*
Categories of Single-Family Dwellings - 1970

Category	# Units (thousands)	Percent
Single-family homes		
Built for sale	496	62%
Built for rent	9	1
Custom-built homes		
Built by general contractor	166	21
Owner acts as gen. contr.	26	3
Built by owner & hired labor	78	10
Built entirely by owner	28	3
Total	803	100

* Construction Reports, Series C25, Characteristics of New One-Family Homes: 1970, U.S. Department of Commerce, (Washington, 1971), p.7.

Life Cycle of the Single-Family Dwelling

The motivation for conceiving a single-family dwelling may vary greatly from one project to the next. If the project is conceived by the homeowner, then it is usually thought of to correct some inadequacy in his present housing. For example, the new home may be in a better location, may be more spacious than his present housing, or may offer a better investment opportunity. The speculative builder, on the other hand, whether he is a builder, real estate broker, or investor, is usually motivated by the profit opportunities associated with residential construction. Most residential projects offer the speculative developer a relatively quick return on his capital investment. For example, the developer of a single lot could expect to sell a completed home within six months to a year after purchasing the land. Obviously, the payback period for large subdivisions is somewhat larger. However, these may be developed on an incremental basis with the construction of roads and utilities staged to keep pace with the construction and sale of the new homes. Thus the total capital investment outstanding at any period in time may remain relatively low when compared with commercial or industrial projects of similar size. Single-family residential developments may also pose fewer long-term management problems to their developers. In most cases, the developer's responsibility for maintenance and repair of the houses he builds ceases shortly after construction

when the house is sold. Compare this situation with the property management problems (e.g., leasing and repairs) faced by the developer of a commercial shopping plaza who may continue to operate the plaza for many years before selling.

A project is usually conceived in terms of the development of a specific plot of land. (This may be less true for the development of custom-built residences, for which the homeowner may have conceived the project in detail long before he finds suitable property.) Preliminary analysis begins with the evaluation of the site to determine its suitability for development. The owner, whether he is a homeowner or developer, must evaluate the engineering properties of the site; its relationship to places of employment, cultural and recreational centers, schools, shopping centers, and transportation facilities; and, finally, its potential marketability in terms of the type of household which would be attracted to the area and what size and price of home would be desired. The latter is particularly important to the speculative builder.

There are really two distinct cycles of design and construction associated with most residential projects. The first involves the development of the site, usually into a subdivision. A "subdivision" is defined as "... the division of a lot, tract, or parcel of land into two or more lots, sites, or other division of land in such a manner as to require provision for a street for the purpose, whether

immediate or future, of sale or building development."* The second involves the design and construction of the home on an individual lot. The owner of the custom-built house may be involved only in the second phase, but it is usually possible to identify both phases for any single-family dwelling. In some cases, different actors may be involved, and many years may separate the initial subdivision of the land from the construction of the home.

In those communities which exercise zoning control over new construction, the subdivision of land into residential lots is usually a closely regulated practice. The developer will find written into the town by-laws a detailed procedure specifying the town officials that must approve the subdivision and the information which must be given to them. Take, for example, the developer of a forty-acre site in a Boston suburb. Before he can subdivide the land into lots, he must first secure the permission of the local Planning Board. A record plat or plan of the proposed subdivision is made by a professional engineer or surveyor. This shows the boundaries of the land, the location of all existing and proposed streets, the boundaries of each lot in the subdivision, proposed drainage, street plans and profiles, and the existing typography of the land.

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* "By-Laws and Regulations of the Town of Dover," (Dover, Massachusetts, 1956), p. 49.

All lots must conform to zoning requirements or variences must be requested. Percolation tests may be required if private sewage disposal systems are used. The developer will provide information concerning the water supply system and details of the sewage disposal system to be used. Upon receipt of the plat, the Planning Board, with assistance from the Board of Health, Superintendent of Streets, and such other town officials as it feels necessary, will evaluate the application. In some cases, public hearings will be held, particularly if the project is large enough to require the town to expand the level of services that it provides (schools, police and fire protection, etc.). At this point, the developer must "sell" his project to the town. Following approval by the Planning Board, the application is forwarded to the Board of Selectmen who may require the developer to post performance bond, guaranteeing completion of the streets in accordance with an agreed time schedule.

In some towns, the design of streets and utilities is left to the discretion of the developer and his engineer. In others, fairly detailed specifications are set forth in the subdivision laws. In the example cited above, the developer must have the streets constructed to rigid specifications under the direction of the Superintendent of Streets. House construction may not begin, nor may any lot be sold, until the street in front of it has been paved and approved by the Superintendent of Streets. Obviously, specific requirements will

vary from community to community throughout the country.

Up until this point in the development process, the owner has dealt with many people and has committed large amounts of money for land purchase and improvements without realizing any returns on his investment. His lawyers have drawn up the necessary papers to purchase the land as well as written several contractual agreements. It may have been necessary to seek additional investors, such as real estate investment trusts, who will contribute some of the equity capital necessary to bring the project to this point in its life cycle. Engineers have performed field tests and designed lots, streets, drainage systems, and utilities. Surveyors have mapped the property in detail and have laid out lot and street lines. Analysts have examined the potential market for the project. The developer has negotiated approval of the project with town officials. A heavy construction contractor has constructed the streets and installed utilities and drainage facilities. This completes the site development cycle of design and construction.

The design and construction of the new home follows a cycle similar to that for developing the residential subdivision. The owner, whether he be a developer or a homeowner, begins with certain design criteria. In the case of the developer, these criteria may be derived from the market analysis and may amount to little more than specifying the number of bedrooms required and the desired

selling price. In other cases, these criteria may be so complete that little further design is necessary. In any event, the owner must appoint a designer. This may be a member of the developer's staff, a practicing architect or an engineer, the builder, a friend of the owner, or even the owner himself. In some cases, the plans may be a repetition of a set the designer has previously used, or even a mail-order set of plans. In other cases, the design may be developed specifically for the owner to meet his particular requirements. The manufacturers of modular and prefabricated homes also are a source of designs. The design often must be approved by a registered architect before a building permit will be issued or a mortgage approved.

When the plans and specifications are completed, the owner may apply for a building permit and construction loan and select a contractor. The architect or the contractor may act as the owner's agent in applying for the necessary building permits. At this time, the owner will be required to submit a record plat of the lot, certified by a civil engineer or surveyor, showing the location and elevation of the house, the location of all utilities and drainage, and the location of the water supply (including the well if on the lot) and the sewage disposal system (if not connected to a community sewer). This plat is usually more detailed than the one submitted for approval of the subdivision. The engineer or

surveyor signing the plat may later be required to certify that details of the drawing are correct as constructed. The construction loan is obtained by the owner from a savings and loan association, a commercial bank, or another mortgage institution. In some cases, the loan may be underwritten or guaranteed by a state or federal agency such as the Federal Housing Administration or Veterans Administration. The owner must usually submit proof that he owns the site, copies of the plans and specifications from which the house will be built, the name of the general contractor who will build the house, and an estimate of the cost of construction. The contractor may be selected in a variety of ways. A developer may have his own general contracting capability or may have worked with a particular general contractor on several previous houses. He may also solicit competitive bids for part or all of the construction work. Similarly, the homeowner may decide to act as his own general contractor, do the work himself with hired labor, or hire a general contractor to supervise the entire construction process. General contractors and subcontractors may be hired on the basis of fixed bids, estimates, or reputation. Frequently in large projects, specialty crews such as electricians, plumbers, plasterers, will be hired to work on all of the houses in the subdivision, moving from one house to the next like on an assembly line. In other projects one crew may do all the work on a particular house before moving on to the

next.

The owner's responsibility for the supervision of construction of the home may be delegated to one of the professionals working for him (architect, landscape architect, or engineer) for different phases of construction - or to a project manager in the case of a large residential development - or he may supervise the contractor directly. The working relationships which will exist on the job are specified in the contracts and agreements between the owner and the contractor. During construction the owner or his agent may do little more than occasionally visit the site to see the contractor's progress. In other cases, he may take a very active role in determining construction methods, materials, and the sequence of operations. The contractor is responsible for purchasing all material called for under the contract and for erecting the building described in the plans and specifications. He supervises the day-to-day work of the men on the job and determines how the structure will be built. The owner, in turn, is responsible for reimbursing the contractor in accordance with the terms of the contract. Reimbursement may be based upon the contractor's completion of some phase of construction such as the foundation or exterior watertight shell, upon presentation of evidence of costs incurred to date, or upon some other pre-determined formula. Frequently the institution supplying the construction loan will specify the method by which the contractor

will be reimbursed.

At various times throughout construction, the project will be inspected to ensure the building is being erected in accordance with plans, specifications, and accepted construction practices. Much of the responsibility for inspection rests with the owner or his agent, but federal, state, and local agencies may also inspect the project at various stages of construction. The Board of Health may inspect sewage disposal and water supply installations. Electrical and plumbing inspectors will examine the work performed by their trades. The building inspector may make a series of inspections during construction. Frequently he must inspect the open excavation before the footings are poured, the completed foundation, the framed house before any lathing or plastering is accomplished, and, finally, the structure. Often he must sign an occupancy certificate stating that all necessary work has been completed before the homeowner can move in.

When construction is completed, a final inspection is made before the contractor receives payment. Sometimes this takes the form of an inspection by the owner or his agent, the lending institution or investors, and the contractor. In speculative projects the inspection may be made by the real estate salesman and the prospective new homeowner. In either case, a list of contractor-responsible discrepancies may be compiled which must be corrected before the builder is released from his contractual obligations (other than guarantee

clauses). Once these discrepancies are resolved, the contractor may receive final payment, and releases are signed by the contractor and the owner. At the same time, permanent financing may be arranged by the homeowner, or additional financing may be required by the speculative developer if the house has not been sold.

B. Multi-Family Housing

Until recently, multi-family housing consisted almost exclusively of low- and medium-rise rental apartments. The past few years, however, have seen significant changes, both in the types of structures built and in the form of ownership, as the cost of housing has risen dramatically. In metropolitan areas high-rise towers have replaced sprawling tenaments as land has become more scarce. In suburban areas garden apartment complexes offering swimming pools, health clubs, and the like are being built in ever-increasing numbers. Condominiums and townhouses are offering to many who desire the convenience of apartment living, coupled with the financial advantages of home ownership, an attractive compromise within their economic means. Their success can readily be seen when one considers that 27.3% of all multi-family housing in 1972 is expected to be in this category - up from 15.8% in 1971 - according to a survey conducted by the National Association of Homebuilders. Single-family detached dwellings are accounting for a smaller portion of the single- and multi-family housing market, dropping from 78.7% to 72.4% of new housing sales.

Life Cycle of a Garden Apartment Complex

A residential developer may view an unimproved suburban site as being suitable for the construction of garden apartments. Several factors may influence this decision. The acquisition or site development costs may be so high that only relatively high-density construction will be profitable. On the other hand, zoning regulations and the character of the community may prohibit - or seriously discourage - construction of high-rise housing. Other apartment complexes in the area may be in high demand. The population in the area may be highly transient - such as near a military base - and adequate housing for such people may not be readily available. In any event, the multi-family residential developer conceives of his project in terms of its potential marketability and in terms of the suitability of available land for such development.

Preliminary analysis, as for speculative single-family dwellings, will be concerned with: 1) determining the potential market for an apartment complex, 2) evaluating the potential site(s) available, 3) developing preliminary design criteria, and 4) undertaking a financial feasibility analysis. The market analysis for an apartment complex will of necessity be of different scope than the one made for single-family housing. The developer of a single-family project is concerned primarily with the immediate marketability of a house. A multi-family developer must be concerned

with the potential market five or ten years hence if he is to assess adequately the economic feasibility of the project. He must accurately predict the long-range demand for different types and sizes of apartments. While the developer of a subdivision can usually modify the plans for remaining homes if he discovers that some are more easily marketed than others, the developer of a multi-family complex does not usually have that option. Therefore he must have a more extensive market analysis to determine the level of rents which will be supported by the local market, the amenities that must be provided to attract people to the complex, the size of the apartments, and the architectural style which will be suitable. It may also be necessary to analyze the expected future growth of the community to establish the long-term viability of the project.

Several forms of the site evaluation are necessary. The first - the location analysis - is closely related to the market analysis. The purpose of the location analysis is to evaluate the potential attractiveness of a site to the market. The developer must evaluate the relationship between the site and the places of employment, shopping and cultural centers, transportation facilities, etc. The second evaluation to be made is a study of the attitude of the community toward multi-family housing. The developer must assess the character of the community in terms of its architectural style,

economic and social values, and possible opposition to multi-family housing. At the same time a study must be made of the legal requirements that must be met by the developer, such as planning board procedures and zoning by-laws. These may specify the manner in which the site can be developed, the density of the housing which will be allowed, and the types of construction materials which may be employed. While some sites are already zoned for apartment construction, it is more often the case that the developer will have to seek a modification of the zoning regulations. While making his site evaluation, the developer may also discover that he will require variences from existing zoning laws, even if the site is zoned for multi-family residential use. Finally, evaluation of the site must include at least a preliminary engineering analysis to determine what improvements to the site will be necessary before building construction may begin.

The developer will prepare preliminary design criteria to guide the architect. These will usually specify the number of units he wishes to build, the type of features he would like to incorporate, and the preliminary budget for the project. Most of the design criteria which the developer formulates will be the product of the market and site evaluation studies and will represent the developer's concept of how he can best attract the potential market. From these design criteria, the architect and engineers will develop

further design concepts to be submitted to the developer for approval.

Concurrent with other evaluations, the developer will have to formulate preliminary budget estimates and to seek financing sources. Budgets at this stage of a project's life cycle will be written in very broad terms, based on estimated costs per dwelling unit or percentage of total construction cost for example. Based upon these figures, the market studies, and preliminary design concepts, the developer can begin to seek external financing sources. As in other types of construction, this is usually accomplished through some combination of the developer, outside investors, and some form of mortgage loan. In some cases, government housing subsidies and/or loan guarantees may also be available.

Because of the difference in the scale of the projects, detailed design for a garden apartment complex will usually be more extensive than that for a single-family dwelling. The structural, mechanical, and electrical systems are usually of such a scale to warrant the services of engineering specialists in each of the areas. Special designs may also be necessary for large-scale water supply and sewage disposal systems. In the case of a garden apartment complex, the services of a landscape architect may be indispensible. The final product of each of these design specialists will be a set of working drawings and/or specifications approved by the owner to guide the contractor during construction.

The primary differences between construction of a garden apartment complex and a single-family dwelling are ones of scale and materials. Just as the elaborateness of the mechanical, structural, and electrical systems justify more intensive engineering, the size of the project and the repetitiveness of the design generally allow the contractor to realize certain economies of scale. By staging construction the contractor can assemble different trades in different units - plasterers in one, electricians in a second, plumbers in a third, etc. Thus an assembly line can be developed in which the construction force moves from unit to unit in a planned sequence of operations. During construction the developer, the architect, and any consulting engineers may make periodic site inspections to monitor the contractor's performance. A clerk-of-the-works may be employed by the owner on larger projects.

III. The Development of Highways and Streets

A. Introduction

Traditionally one of the most important segments of the construction industry, highway construction in 1970 cost almost $10 billion, representing over 10% of the value of all new construction put in place and 35% of all new public construction. Private construction of streets is relatively insignificant, a small fraction of one percent of all new construction.

B. Life Cycle of a Highway Project

Conception

The conception of a highway project is usually the result of some form of user needs analysis. Starting with an inventory of roads, planners in the state, county, and local highway departments analyze each road in terms of its ability to meet present and future highway standards. A project may be conceived as part of a national, regional, or municipal highway plan. Radial expressways leading from core cities outward to the suburbs are typical examples of this type of road, as are the circumferential highways and bypasses ringing the cities. The National System of Interstate and Defense Highways is a prime example of roads being developed as part of a national master plan. In some cases, a project may be developed to improve the safety of an existing highway or simply to improve the flow of traffic through the use of signals, restricted-use lanes (bus lanes, truck lanes, etc.), or protected turn lanes. In other instances, complete rebuilding of the roadway may be necessary to increase capacity. Finally, a road may be designed as part of a planned development project to provide access to a location for a new industry or housing. In each case, the road is conceived as a means of connecting vehicle origins and destinations in an economic and efficient manner. Priorities among projects are established primarily on some form of benefit/cost ratio, although political forces may influence

these priorities considerably.

Source of Funding

Once a particular project is conceived, any further planning requires identification of a source of funding. Public highways are financed through revenue from two sources: taxes and tolls. Authorization to use taxes for highway construction is obtained from federal, state, county (or regional), and local governments, while toll facilities are usually developed by independently financed bridge and turnpike authorities.

Approximately 40% of the annual construction expenditures for highways and streets comes from the federal government as part of the Federal-Aid Highway Program. The program provides for payment to the states a portion of new construction and major upgrading costs on designated highways. At present, the Federal-Aid System includes the 42,500 miles of the National System of Interstate and Defense Highways and 869,764 miles of primary, secondary, and urban roads (the ABC System). The federal government, which bears 90% of the cost of constructing the Interstate System, has authorized expenditures of over $4 billion per year for completing the proposed system. The annual authorization for construction under the ABC Program (50% federal aid) is currently $1.425 billion. Funds are apportioned to the states on the basis of various formulae relating system mileage, population, area, and other factors. The states then submit projects to the Federal Highway Administration for ap-

proval. At least 1.5% of the apportioned funds must be used for planning or research activities.

In addition to the Federal-Aid Highway Program, there are state aid programs involving state, county, and municipal governments. In Massachusetts, for example, roads qualifying under Chapter 90 of the Statutes receive 60% funding by the state, the remainder of the cost being split between the county and the town.

There are also projects which are financed entirely by one of the governments involved. The Bureau of Public Roads constructs roads for various public agencies, principally for the National Forest Service and the National Park Service. Work was in progress on approximately $84 million of such roads at the beginning of fiscal year 1969. State-financed projects may include access roads to state parks and beaches. Municipal funding is usually restricted to maintenance and spot improvements.

Preliminary Analysis

Preliminary analysis involves the formulation of alternative proposals for satisfying user needs. In the case of new construction, this may take the form of a corridor study to determine the relative feasibility of several possible routes connecting the terminal points and possible locations for interchanges connecting the new route with existing routes. When a project is designed to upgrade an existing roadway, the preliminary analysis may be limited

to consideration of different design strategies. Traffic projections, origin and destination studies, and benefit/cost figures are used in determining the level of service to be provided. Preliminary borings, aerial photographs, and topographic maps are used to evaluate the terrain. As part of the corridor study, an environmental impact study is performed on all federal aid projects. When the preliminary analysis is completed, a public corridor hearing is held to enable all interested parties to examine the proposals and to make comments. After the hearing, the proposals are forwarded with recommendations to the funding agencies involved (e.g., the Federal Highway Administration) for approval. Upon approval of the corridor, the design phase begins.

Design

After approval of the corridor and/or design strategy, a detailed analysis must be made to determine the exact location of the roadway and the design of the roadbed and all related structures. The route is surveyed, borings are made as necessary, and the detailed design is developed. When the plans and specifications have been developed, a second hearing - the design hearing - is held. Again, the comments received at the hearing and the final plans are submitted to the funding agency for approval. When this approval is granted, right-of-way acquisition may begin. Finally, a construction contract is awarded on the basis of a competitive

bid.

Right-of-Way Acquisition

The method by which highway sites are acquired is quite different from that in which sites are normally acquired. Because the state has the power of eminent domain and because of the continuous nature of the highways, once a route has been approved, there is little question about which sites will be acquired. An appraisal is made of all property on the route, the state establishes a price to be paid for the land and any buildings which may be on it, and ownership of the property is turned over to the state.

Construction

During construction the contractor's work is monitored by the lead agency to ensure compliance with the contract documents and to determine the amount of progress for which the contractor is entitled to payment. In most major projects the lead agency is the state highway department. In Massachusetts, for example, the lead agency for a Federal-Aid Project is the Department of Public Works (DPW). The state's resident engineer determines the contractor's progress on a biweekly basis. An application for progress payment is forwarded to the District Construction Engineer for approval. The Commissioner of Public Works authorizes the State Treasurer to pay the contractor for the work accomplished to date, less any retainage. The Federal Highway Administration then reimburses the

state from the Highway Trust Fund.

C. Key Actors Unique to the Highway Industry

There are several key actors who can be identified with highway construction. The first are the legislative bodies. It is these bodies on the federal, state, county, and municipal level who have established the framework within which the highway project is developed and who initially allocate funds to pay for highway projects. The Federal Highway Administration and the state highway departments also play key roles in the development of most highways.

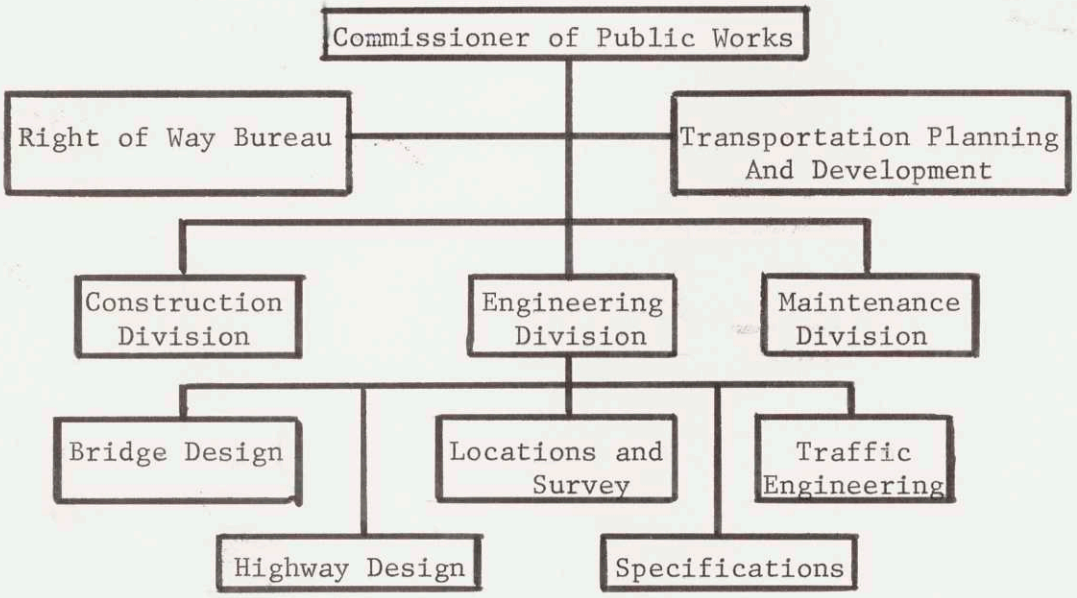
The Federal Highway Administration

The Federal Highway Administration's primary role is to apportion federal funds to the states and then to receive and approve the states' use of these funds. The FHWA is organized into nine regions. There is a division office in each state in a region. Each state is organized into districts (e.g., Metropolitan Boston) and further into areas which correspond to the state highway department districts. Each area is represented by an engineer who is responsible for all federal aid projects within his jurisdiction. He reviews and makes recommendations on all projects within his area submitted to the Federal Highway Administrator by the state for inclusion in the program. During construction the area engineer makes periodic on-site visits, primarily to monitor the inspection systems used by the states and contractors and to review progress. At the end of construction

Figure 3.1

Organization Chart

Massachusetts Department Of Public Works



he certifies that the highway has been constructed in accordance with federal standards. The FHWA also plays an important role in projects for other government agencies by acting as the design and contracting agent for federally-owned roads.

State Highway Departments

Although most major highways are constructed under the Federal-Aid Program and must meet FHWA approval, the real focus during most of the development process is within the state highway department. Typically, a state highway department will be organized into a series of functional units specializing in different phases of a highway's life cycle (Figure 3.1). A transportation planning division will normally be responsible for maintaining the inventory of roads, for evaluating the adequacy of roads, and for developing traffic forecasts. It is in this division that most projects are conceived. The engineering division is responsible for the preliminary analysis of state highways. For those design studies which are contracted out to consulting firms, the engineering division acts as monitor and advisor. This is frequently the case for large or controversial projects. Other projects may be designed completely in-house by department engineers. The Right-of-Way Bureau is responsible for appraising all property to be acquired and for initiating the necessary documents transferring control from the owner to the state. The construction division administers all construction contracts,

providing field supervision and inspection through the field or resident engineer assigned to the project. The resident engineer:

1) Inspects all work performed by the contractor to ascertain compliance with contract drawings and specifications,

2) Determines the progress of the contractor to date and the amount of payment due the contractor under progress payments,

3) Manages the inspection staff and inspection records,

4) Recommends contract modifications to the district construction engineer,

5) Interprets contract documents.

Finally, the maintenance division is responsible for all routine maintenance and repair of state roads.

IV. Commercial Development

A. Introduction

Commercial development has become an increasingly important sector of the construction industry. In 1970 the value-put-in-place of $9,754,000,000 represented over 10% of all new construction and almost half of private non-residential building construction. Included in this category are all office buildings (except those at industrial sites or built by public utilities for their own use), warehouses, storage buildings, and buildings used in the wholesale, retail, or service trades. In so much as they may be part of a commercial project, auxilary services such as parking lots, streets, sidewalks, sewer and water facilities are also included under this type of con-

struction.

B. Life Cycle of a Commercial Development Project

Conception and Preliminary Analysis

Because of the tremendous variety in the types of projects included under commercial development, it is possible to speak of the conception of this type of project only in relatively broad terms. As in residential construction, it is useful to distinguish between two types of owners of this type of project. The first type includes those owners who are building for themselves as prime tenant and whose projects are designed and constructed to fit their relatively unique needs. The second type of owner includes the developer whose projects are constructed primarily as speculative ventures, although one or more of the prime tenants may have been identified early in the project's life. There are many reasons why a new project could have been conceived by either type of owner. The most prevalant would appear to be a desire to serve additional market areas by making available new facilities and products. The type and size of the facility is usually determined after studying the size of the market (population and area), the proximity and demand for similar existing facilities in the market area, and the availability of land suitable for development. Other reasons for conceiving a project might be to upgrade or rehabilitate existing commercial space (particularly under urban redevelopment programs) or to expand or replace existing space

which is no longer adequate.

During preliminary analysis the owner determines the feasibility of the proposed project. A detailed analysis of the available market may be made for the purpose of locating tenants and for determining the availability of customers for those tenants. Frequently, this analysis is comprised of a description of each identifiable market and its relationship to the proposed sites. Available sites will be studied to determine the one most suitable for the project. Preliminary financial arrangements may be made. Legal constraints, especially zoning ordinances, will be examined and, where necessary, modifications will be requested. In the case of some of the large urban renewal programs, commercial developers may begin laying the groundwork for future approval by legislative bodies and executive agencies. An additional important step at this stage of development is the selection of an architect by the owner to assist him in defining the project parameters.

Site Acquisition

Often the success or failure of a particular commercial development will depend to a great extent upon the skill with which the developer assembles the site. The subterfuges to which some developers have resorted to avoid disclosing the identity of the true purchaser are well-known. Equally well-known are the instances where the commercial developer has acquired all but a small portion of the pro-

posed site and has been forced to pay an outrageous price for the remaining section. Recently the urban developer has been assisted in site acquisition by various urban renewal authorities. These authorities are able to condemn property under the power of eminent domain and then may sell the assembled parcel back to a developer upon presentation of an acceptable proposal for redevelopment of the land. In many cities, awards for such projects are made on a competitive basis in which the developer is required to undertake much of the preliminary analysis and design without an assurance of return on his investment. The amount of risk involved for the unsuccessful developer may be high when one considers that the successful developer of a major urban commercial redevelopment project in Worcester, Mass. incurred out of pocket expenses in excess of $100,000 before being awarded the project.

Design

Once a project has been defined, its feasibility established, and a site located, the architect can begin formulating building concepts which will meet the owner's needs. Early in the design stage, the basic shape, size, and style of the building will be determined as well as the requirements for the structural, mechanical, and electrical systems. Cost estimates of alternative designs will be made to assist the owner and the architect in arriving at a well-balanced solution. When agreement is reached on the basic design, the detailed drawings and specifications may be prepared. Upon ac-

ceptance of these plans and specifications by the owner and the municipal building and planning agencies, selection of a contractor is made on either a competitive bid or a negotiated basis.

Construction

Before construction may begin, a building permit is usually required by the municipality in which the structure is to be located. On the basis of applicable codes and statutes, the municipality grants permission for the selected contractor to build a structure in accordance with submitted plans and specifications. Often the plans must be certified by a registered architect or civil engineer, and in some municipalities the contractor must be licensed as well. During construction, the architect and owner monitor the contractor's progress. In larger projects, the owner employs an on-site clerk-of-the-works to ensure that work is carried out in accordance with the plans and specifications. The architect periodically certifies the contractor's progress to the owner for payment. When the job is completed, the architect prepares a list of discrepancies, if any, for the owner. Once these have been rectified, the architect may be required to certify to the municipality that the building has been constructed in accordance with the filed plans and specifications. When the municipal building department is satisfied that the building meets safety and habitability requirements, it may issue an occupancy permit.

Tenant Occupancy

In commercial construction there is often a considerable amount of fitting out required by the tenant in addition to the work carried out by the general contractor and his subs. The installation of special purpose equipment, store fixtures, and floor, wall, and ceiling finishes are often the responsibility of the tenant and may not be included as part of the owner's construction contract. In many cases, this may be a major operation requiring additional architects, engineers, and contractors.

C. Key Actors in Commercial Development

The responsibility for over-all management on a commercial project is usually shared by the owner and the architect, the balance being determined by the relative sophistication of the owner and his confidence in the capabilities of his architect.

The Owner

During the initial phases of project development, the owmer's major role is to develop the concepts of the project and to analyze its feasibility. The owner-occupant will more than likely be analyzing the project in terms of his specific spacial requirements, while the owner-developer will usually be more concerned with maximizing the amount of rentable space. The owner is responsible for arranging the financing of the project, whether through borrowing, equity, investors, or combinations of the three. He usually will

retain legal counsel to assist him in contractual matters as well as during land purchase. The owner will seek the necessary zoning variences which may be necessary. He also will begin lining up tenants for the project, the commitment of which will often have considerable influence on the availability of outside funding. In cases where long-term lease arrangements are negotiated with such tenants, the tenant also may exert a strong influence during the design stages.

As more definitive plans are developed, the owner will be reviewing them to determine if they meet his conceptual and budget requirements. Of major importance to most commercial owners are the flexibility of the major structural, mechanical, and electrical systems to accomodate different tenant needs and the marketability of the commercial space to the proposed tenants. During the design stage, the major role of the owner will be to select from the alternatives developed by the designers, those which best meet his performance-investment criteria. Once these decisions have been made, the owner can request that the architect prepare the working drawings and specifications.

The owner decides how to hire a contractor, what legal agreements will be made, and how the project will be financed during construction. During the construction, it is part of the owner's role to oversee the contractor's work to make sure he is getting the quality of work and materials called for in the specifications.

The major part of this role is usually carried out by the clerk-of-the-works or resident engineer. In the case of an owner who continuously has projects under construction, this person may be a regular employee. In most cases, however, the architect may be requested to employ such a person for the owner.

The Architect

As in most building construction, the architect plays the major role in designing the facility. The American Institute of Architects in its "Statement of Professional Services" outlines the role of the architect during the project's development. During the "Schematic Design Phase" the architect analyzes the project requirements with the owner and develops schematic drawings showing possible relationships among facilities, floor plans, various elevations, etc. A Statement of Probable Construction Costs, based upon unit costs, is prepared to assist the owner in evaluating the design alternatives open to him and to enable him to begin to formulate the capital budget. In the "Design Development Phase" the architect refines the schematic design into a more detailed plan. Building materials and structural, mechanical, and electrical systems are established. It is during this stage that most of the decisions on details which may be important to the owner must be resolved. At the conclusion of this phase, the design development drawings and a refined Statement of Probable Construction Costs are submitted to the owner for approval.

When all major decisions have been made and the design development approved, the architect may begin to translate these into contract documents to be used during construction. Working drawings showing all construction details and materials must be produced. The technical specifications describing the level of quality desired must be written. At this time, the architect will probably be directing quite closely the structural, mechanical, and electrical engineers, as well as other technical specialists that are on his own staff or hired by him as consultants. The architect also aids the owner and his legal counsel in preparing the other necessary legal documents such as the advertisement, the proposal, and the general conditions. During the "Bidding or Negotiation Phase," the architect may advise the owner on the qualifications of the bidders or may assist in interpreting the contract documents. The final stage is the "Construction Phase." The A.I.A. points out that the architect does not supervise or direct the work and only makes "periodic" site checks under the normal agreements. In most major projects, however, the owner will provide for a full-time clerk-of-the-works or resident engineer as pointed out earlier to maintain continual surveillance of the contractor's work. In addition to the periodic site visits mentioned above, during the construction phase the architect reviews and approves shop drawings prepared by the contractor or his vendors, makes revisions to his own drawings where necessary, prepares change orders

covering work modifications approved by the owner, certifies the contractor's progress to the owner for payment, and expedites the details involved in closing out the contract at the completion of construction.

The Engineer

In most types of building construction, it is necessary to bring together many technical specialists as well as the "aesthetic" specialists - the architects. In the design of commercial buildings, the engineer assists the owner and the architect in designing the components of the building so that they will fuction technically as well as aesthetically. There are three major types of engineers who assist in the design of almost all commercial construction - structural, mechanical, and electrical. Many larger architectural firms will have specialists in these fields on their staff. Others may employ engineering firms on a regular basis to handle the design of the technical components of the project. The importance of the role of each of these engineers in the design process can be quite variable, depending upon the attitude of the architect. In some cases, for example, the architect may decide upon the structural system to be employed and the location and approximate size of all structural members before the structural engineer even receives the job. In other cases, the structural engineer may be an active participant on the design team during its earliest stages of schematic design,

proposing alternative systems which are compatible with the owner's and the architect's building requirements. Similar observations may be made about the mechanical and electrical engineers. Specialists, such as elevator engineers and soil engineers, may be brought in if conditions merit.

In addition to the role which the engineer plays during the various design stages, he may also have an important role during construction. Because the clerk-of-the-works will often not have the technical expertise necessary to monitor adequately the quality of work performed by the contractor and to advise the contractor on technical problems encountered during construction, the engineer may be retained during construction to give assistance where necessary.

The General Contractor

The general contractor in commercial construction is responsible for converting the contract design developed by the architect and engineers into the structure. The scope of the contract may be anything from providing a shell to be turned over to a tenant for completion, to constructing and outfitting the complete building. The contractor may be responsible for all construction on the site, or may only be responsible for a small portion of it. In some cases, the general contractor may employ all the trades necessary to carry out the contract. In other cases, the general contractor may amount to little more than a coordinator of specialty subcontractors, with

no in-house construction capability.

Common to all projects is the role of the general contractor as the coordinator and schedular of the construction trades over which he has control. Under some form of agreement to the owner, the contractor supplies the manpower and materials necessary to construct the building. There are usually two people within the construction firm who exercise managerial authority over any project: the project manager and the field superintendent. The contractor's project manager is usually thought of as being located within the firm's office and having control over all phases of the firm's involvement with the project. The project manager may act as the spokesman of the firm before the owner and is concerned with negotiations on extra work, with purchasing, with obtaining subcontractors, and generally overseeing the project from a time and cost standpoint. He may also be involved in coordinating the use of manpower and equipment within the company on other projects. The field superintendent, on the other hand, is the contractor's field representative, overseeing and coordinating the day-to-day operations of the trades on the site. He is responsible for the utilization of the manpower and equipment supplied to him and oversees the quality of the work performed at the site.

V. The Development of Industrial Projects

A. Introduction

Industrial projects form the second most important category of

Table 3.3*

Standard Classification for Manufacturing Industries

SIC Group	Industry
19	Ordnance and accessories
20	Food and kindred products
21	Tobacco manufactures
22	Textile mill products
23	Apparel and other finished products made from frabics and similar materials
24	Lumber and wood products, except furniture
25	Furniture and fixtures
26	Paper and allied products
27	Printing, publishing, and allied industries
28	Chemicals and allied products
29	Petroleum refining and related industries
30	Rubber and miscellaneous plastics products
31	Leather and leather products
32	Stone, clay, glass, and concrete products
33	Primary metal industries
34	Fabricated metal products, except ordnance, machinery, and transportation equipment
35	Machinery, except electrical
36	Electrical machinery, equipment, and supplies
37	Transportation equipment
38	Professional, scientific, and controlling instruments; photographic and optical goods, watches and clocks
39	Miscellaneous manufacturing industries

* Standard Industrial Classification Manual, Bureau of the Budget (Washington, 1967), pp. 37-200.

private non-residential building construction. The value-put-in-place of $6,538,000,000 in 1970 represented over 30% or new private, non-residential building construction and 7% of all new construction. The U.S. Department of Commerce defines industrial projects as "... all buildings and structures at industrial establishments as defined in major groups 19 to 39 of the Standard Industrial Classification Manual" (Table 3.3). As in commercial projects, auxiliary facilities such as streets, parking lots, sewers, etc., are included in this total when they are an integral part of the project.

B. Life Cycle of an Industrial Project

In order to better inderstand the process of developing an industrial project, it is useful to define three different types of projects: the first is one in which an industrial firm acpuires an undeveloped site and constructs a plant to its own specifications; in the second type, a developer acquires control of a relatively small site and improves it, at least to the point of providing necessary access and utilities before turning all or part of the site over to the industrial tenants (often termed an unplanned development); the third type of project is the planned industrial development or industrial park, differing from the second mainly in terms of size and the degree of control exercised by the developer in managing the project.

In the following sections, the latter two types of projects are analyzed in order to better understand the types of

decisions to be made and the actors involved in making those decisions.

Conception

The conception of any industrial development, whether unplanned or an industrial park, occurs when the developer realizes that a need for industrial facilities exists and that a parcel of land can be improved to meet this need. The motivation behind the conception could take on any of several forms. Private developers such as real estate brokers, contractors, or industrial development corporations could conceive of a project as a profit-making venture. Utility companies and railroads have often planned industrial projects in order to attract firms which would be heavy users of their services. Public and community development organizations have sought to attract industrial development as a means of providing new jobs (as in the Southeastern United States) or to replace defunct industries such as the New England Textile Industry. In addition, these groups often seek to develop industrial sites as a means of broadening the community's tax base.

Preliminary Analysis

Whatever the motivation of the developer, extensive preliminary analysis is essential to any successful project. There are three major factors to be considered at this time: the marketability of an industrial project, the attitude of the community towards indus-

trial projects, and the economic feasibility of the proposed project. During preliminary analysis the developer may deal extensively with municipal officials, as well as marketing and financial analysts, to determine the feasibility of the project.

Site Acquisition

If the project appears feasible, the developer next must determine the suitability of the site for development and make arrangements for gaining control of it. The ideal site has been described as follows:

1) It is a level, solid, well-drained piece of land;

2) There is room for expansion;

3) There is excellent and varied transportation available immediately adjacent to the site;

4) There is "large capacity" availability of water, sewer, and electrical power;

5) The site is near a good supply of necessary materials and labor and is surrounded by an active and prosperous market.*

If the site is being acquired with the intention of developing it for a particular type of industry, consideration should be given to the specific user requirements which might be placed upon it,

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* Stuart P. Walsh, "Industrial Land Development," Real Estate Encyclopedia, ed. J. Friedman, (Englewood Cliffs, N.J., 1960), p. 1023.

especially size and land-use restrictions.

If he desires to acquire the site (or sites) in question, the developer must next examine the types of financial arrangements which may be possible. The development is often highly speculative in nature, and financing the acquisition of a site can be difficult. If the developer does not have sufficient financial backing to purchase the site outright, he usually must negotiate an agreement with the original owner(s) which provides for deferred payment. In some cases, this may take the form of land contract under which the owner agrees to sell parcels of land at a predetermined price to the developer as he is able to use them. Other possibilities include the ground lease and the purchase money mortgage in which the seller agrees to extend credit to the developer for a portion of the purchase price. The result of each of these methods is to allow the developer to minimize his cash investment in the land and to keep cash available for site development and building construction if necessary.

Site Development

It is at the site development stage when significant changes can be readily seen between the scope of work required for an industrial park and that necessary for an unplanned development. Improvement of a smaller site may involve little more than clearing and leveling the site, providing minimal drainage, and laying out the individual sites, if any. If the developer is not constructing the plants, the

development process is halted at this point until a willing buyer or leasor can be found. Development of an industrial park is much more involved. A well-conceived development plan is essential to the long-term success of the park. Since this type of park is usually developed over a period of several years, early attention must be given to the staging of the site improvements and to conceiving a site plan which can be readily adapted to changing market conditions and occupant requirements. The developer must determine the size and shape of the lots to be offered, as well as the facilities to be installed to serve the plants. Streets, storm drains, electricity, gas, drinking water, process water, and sewage disposal systems will all have to be planned for. In some cases, it is possible to have these designed and constructed by the municipality or utility company involved. In other cases, the developer may construct the facilities and later turn them over to the community for operation and maintenance. Since one of the major advantages of industrial parks to the occupants is the compatibility of land use within the park, the developer must begin to formulate the restrictions and controls which will be written into deeds and leases to protect the character of the park and the property value of the occupants.

When the developer has thoroughly planned the character of the park and the facilities to be provided, construction may begin. Because a major portion of the financing for site development is usu-

ally required to be the developer's equity, the initial construction may be quite modest. In fact, substantial site improvements may not begin at all until one or more major tenants for the park can be located. As an indication of the magnitude of costs involved up to this point, it has been estimated that "other development costs such as engineering, real estate costs, commissions, advertising, legal fees, and land loss due to unsalable land (e.g., roads) may equal the cost to the developer of the land and utility installation."*

Building Construction

It can be stated that the developer's major role is to create an environment which is attractive to an industrial tenant. In some cases, this may mean simply providing an improved site which the tenant may either lease or purchase. The tenant then constructs his own buildings, arranging for their design and construction himself. In other cases, the developer may become involved actively in the construction of the buildings at the site on either a speculative or custom basis. The developer may often be faced with a perplexing problem in determining how to dispose of the sites once they are improved. In order to attract tenants to the development, he may construct one or more shells which he feels fit the needs of the type of industry he wishes to attract. However, because of the specula-

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* William N. Kinnard & Stephen D. Messner, Industrial Real Estate, (Washington, 1971), p. 569.

tive nature of this type of project, the developer often must finance most of the cost of construction through equity capital. This is usually much less of a problem after one or more major tenants have entered the park, however. Financing is much easier to obtain, both for site improvements and building construction, if the developer can show to the bank a firm commitment from a "national" firm.

Many developers will be organized in such a manner as to provide custom construction services to their tenants. As well as providing additional control over the facilities which are built in the park, the design and construction of the industrial plant affords the developer with an opportunity for increased profits. The occupant gains obvious advantages by turning over the responsibility for designing and constructing the facility to a developer who is often more familiar with local building practices and regulations. In some cases, the developer may retain ownership of the buildings and lease the custom-made building to the industrial firm. In other cases, the developer will act as the firm's construction agent or manager, serving as an intermediary between the new owner and his architect/engineer and contractor.

C. Key Actors in Industrial Construction

The key actors in industrial construction are very similar to those found in commercial construction. In fact, the major difference between the two types of construction lies in the relative importance of

the architect and the engineer and, second, in the emphasis of the owner/developer.

The Architect/Engineer

Whereas the architect is in charge of the design of most commercial projects, the importance of his role may be greatly diminished in the industrial project. The design of the project is often dictated much more by the engineers working for the developer and the tenant than by the architect. An industrial process engineer will often determine the physical layout of the plant and the facilities which will be required. The program of site improvements and the site subdivision plan will often be developed by a civil engineer, rather than an architect. The architect, if employed at all, will be engaged primarily to develop plans for any integral office space and to advise on desirable finishes for the plant area. Major engineering firms who undertake the design of industrial plants will often be engaged by the developer or tenant on much the same basis as the architect in the commercial or residential project, and may act as the client's advisor and agent, as well as designer.

The Owner/Developer

As has been noted, the owner/developer of an industrial project can take several different forms. At one extreme, one has the real estate broker who acts as the intermediary between the original owner and an industrial client desiring new land. At the other end of the

spectrum is the industrial developer who acts as real estate broker, owner, investor, designer, and constructor of complete industrial facilities. In between these extremes is the site developer, who assembles and improves industrial sites for sale or lease, and the industrial firm that purchases a site and contracts for the design and construction of its own plant. The decisions which the owner/developer must make are not unlike those made by the owners of other types of projects. He must first determine the project's feasibility and must also be responsible for the continual re-evaluation of the project as it becomes better defined. He is responsible for the selection of the site and for determining how the site, as well as the design and construction of the project, is to be financed. He must select a design agent, either from within his organization or from a consulting firm, and eventually must select and approve a design for improvements to the site or for structures erected on the site. He must select contractors to carry out any site improvements and building construction. Finally, he must prepare the building for occupancy by his personnel or by an industrial client.

VI. The Development of Public Educational Facilities

A. Introduction

The construction of public educational facilities today represents an annual expenditure of more than $5 billion, over 6% of the value-put-in-place of new construction. The importance of school

construction becomes more apparent when one realizes that educational facilities represent over 50% of new public building construction and 20% of all new public construction. Included in this category of construction are primary, secondary, college and university level buildings; laboratories; science buildings; libraries; art galleries; and museums.

B. Life Cycle of the School Construction Project

Conception and Predesign Planning

Analysis of physical plant utilization and of educational program requirements should be part of the long-range planning of both school officials and their governing boards. When program requirements and the existing plant capabilities are found to be incompatible, further study is necessary to determine how the existing plant may be remodeled, expanded, or replaced to meet the program requirements. During predesign planning, these program requirements must be further defined by the system's educational planner in conjunction with teachers, school administrators, district board members (or in the case of the public university, the board of trustees), and consultants. At this time, decisions may be made as to the types of facilities to be included in the building program, the projected enrollment, and the capacity of the district or state government to pay for new facilities. An evaluation must be made of the present inventory of facilities to determine how they are being used. Also

at this time it is often necessary to obtain permission and funding from the appropriate legislative and executive bodies to carry out further planning.

Site Acquisition

Once some of the basic decisions regarding the type and size of the proposed facilities have been made, the planning team must begin to make decisions as to the site to be used for the school. In many cases, a decision will be made to expand an existing facility on a site already controlled by the district board. In other cases, however, especially in the urban school, expansion on the existing site is almost impossible and an alternative solution will have to be found. There are usually three possible sources of new school sites. In some instances, a site may be donated to the district by some benefactor to be used as a school site. Qualifying as a charitable contribution, this method has obvious advantages to both the district and the benefactor. More often, however, the district must purchase the site, either on the open real estate market or under the district's power of eminent domain. When the district must purchase the site, there are many factors to be considered. If the new facility has been conceived as a neighborhood school, attention may be focused upon finding open land within walking distance of the pupils' homes. Coordination may be necessary with the district or regional planning board to locate available sites which will be compatible with pres-

ent and future community growth. Additional coordination may also be necessary with other public agencies and utilities to determine the availability of adequate electricity, sewage systems, gas, water, fire protection, and traffic handling capacity. The ease with which the site can be adapted to school use as well as its size and shape are other important considerations. Once an acceptable site has been located and appraised, its purchase may be authorized and funded by the district government, or in some cases by the state.

Schematic Design

With the program parameters determined, the size and use of the facilities projected, the available funds determined, and an acceptable site acquired, the architect may begin to transform the requirements and constraints into general building concepts. Cost studies are conducted to make preliminary budget estimates. The schematic design, the educational program, and the cost estimates are then submitted by the building committee via the district board to municipal and state officials for review and approval.

Design Development

Upon acceptance of the schematic design and preliminary cost figures, the design team can develop more detailed studies of the proposed facilities, including large-scale plans and working models of the site and building. Decisions are reached regarding the types of structural, mechanical, and electrical systems to be employed.

Equipment and furniture requirements are determined and planned for. General provisions of the specifications are determined. In a major project, such as the construction of the University of Massachusetts campus at Columbia Point, considerable attention will be focused at this time as to how the project will be constructed. Cost estimates are updated as the design becomes more refined. When completed, the architect presents the design to the district building committee for review and approval.

Construction Documents and Bidding

With the design approved, the architect must next prepare the construction documents used during bidding and construction. Working plans and contract specifications are developed. A final prebid cost estimate is made, and funding for construction of the project is established. At this time, or before, the district board may be required to go before its electorate and request authority to issue bonds to cover the cost of construction or to transfer existing funds to cover the cost of the project. When all necessary funds have been allocated to the project, the board is usually required to secure permission from the district and the state to receive bids. When this and other legal commitments have been met, the project is advertised for bid. After they are received, the bids are evaluated by the building committee, the district legal counsel, and the designer to determine their completeness, the qualifications of the bidders, and the rea-

sonableness of the bids received. In public construction the award is made to the lowest qualified bidder. Selection is made on this basis, and construction commences.

Construction

At a preconstruction meeting the architect, district board, and the selected contractor may discuss the schedule and any logistical problems which may not have been apparent previously. This may be especially important in jobs where construction may disrupt existing school routine. The preconstruction conference also gives the contractor an opportunity to express his needs and concerns relative to the project.

During construction the contractor's work is monitored by the architect and a clerk-of-the-works employed by the school district or by the architect on behalf of the district. Regular job meetings may be held with the contractor, his subcontractors, the clerk-of-the-works, and the architect in order to resolve any scheduling, material, or design problems encountered. The contractor submits claims for progress payments to the architect for certification, and the district pays the contractor the certified amount, less any retainage. When construction is completed, any discrepancies are corrected by the contractor, a final audit is prepared by the funding agencies, and all parties receive final payment. Upon receipt of an occupancy permit issued by the building department the new facility is ready for use.

C. Key Actors Unique to Educational Projects

The key actors found during the development of a school project are similar to those found in most building projects. The roles of the architect, engineer, and contractor are almost identical to their roles in commercial projects, and have been described in detail under that topic. The actors having important roles in the conception and predesign planning of elementary and secondary public school projects, as well as those who exercise a key role in the review and approval process, are somewhat unique. The role of these individuals is briefly described below.

District Personnel

District personnel play the major decision-making role in the conception and predesign planning stages. In most cases, the district has a role similar to that of the owner in a private building project. According to the Council of Educational Facilities Planners, there are four key personnel within the district structure who can be identified as managers having responsibility over a project. The chairman of the school board holds ultimate authority on the dispensation of all funds allocated for school construction. He is authorized to engage the architect and other consultants, as well as to award the construction contract and to modify all such contracts as necessary. Through his appointive powers, he establishes the building study committee and may determine its chairman. He plays a key role in developing the planning organization which formulates and carries out the building program. The second key actor in this development

process is the superintendent of schools for the district. As the leading professional educator within the district, he plays a major role in analyzing the existing facilities and in undertaking the long-range planning in both the educational and the building program. It would be a fair comparison to equate the district chairman and the superintendent of schools to the chairman of the board and the president of a commercial or industrial firm, respectively. Major policy decisions will usually be reserved for these key actors, as well as major financial questions and problems which require the establishment of priorities among each of several projects. The third key person is the chairman of the school building committee. This person will usually be a member of the school board, although he may be someone from the staff of the district superintendent. His role is to coordinate and direct the activities of the committee throughout the planning, design, and construction stages. In some districts there may be a school facilities planner who acts as the key man in determining the educational program requirements and the building program requirements. He is usually a full-time member of the district superintendent's staff and would be a member of the school building committee. The other personnel on the school building committee may include officials of existing schools affected by the building program, district board members, teachers, townspeople (e.g., a local contractor or educator), and, upon selection, the

architect.

State Agency Personnel

In addition to district personnel there are a number of state agencies that possess a review and approval capacity with respect to school construction. Because almost all states provide some form of financial aid to the districts for school construction, there is usually some form of the School Building Assistance Bureau within the State Department of Education to administer the program. The Bureau provides technical planning assistance to the districts and reviews all drawings, cost estimates, and specifications. The Bureau frequently aids the districts in planning the long-range programs, as well as in developing and evaluating the detailed information required for current projects. The Bureau is also responsible for determining the amount of state aid available to the districts for construction and for approving district use of these funds.

While the School Building Assistance Bureau evaluates a school construction project from the standpoint of meeting certain educational program and cost requirements, other executive agencies review all plans and specifications for technical adequacy. The Department of Public Health may review plans for conformance to health standards, especially with respect to water supply, sewage disposal, and cafeteria facilities. The Public Safety Department is concerned

with the provisions in the plans which affect the safety of the occupants in case of fire and which protect the occupants of the buildings from various hazards.

CHAPTER 4

PROJECT MANAGERS IN THE CONSTRUCTION INDUSTRY

I. The Survey

In order to gather information about project managers in the construction industry, a survey was conducted of representatives of many different organizations and project types. The purpose of the survey was to gather information to answer the following questions:

1. Who are the project managers in the construction industry?
2. What is the characteristic of their backgrounds?
3. What is the role of the project manager?
4. What skills and substantive areas of knowledge are important to him in his role as a project manager?

Description of the Survey

The questionnaire was divided into three parts, A, B, and C. In part A, the participant was asked to describe his educational and professional background. In part B, he was asked to describe in some detail his present position and his role in a recent project. In the final section, the respondent was

Table 4.1

Classification of Selected Participants

Type Organization	Possible Replys
Private Owners and Developers	180
Architects and Engineers	66
Contractors	90
Public Agencies	
Building	45
Highway and Streets	54
Heavy Construction	15
Construction Managers	6
Total	456

requested to describe what skills and areas of knowledge were important to him as a project manager. A copy of the survey questionnaire is included as Figure 4.1.

The Survey Participants

Over one hundred and fifty different organizations were selected to participate in the survey. Table 4.1 provides a classification of the selected survey participants. The organizations were chosen from several directories, including the Engineering News Record Top 500 Design Firms and Top 400 Contractors, the membership of the Associated General Contractors of America, the Fortune "Directory of the 500 Largest U.S. Industrial Corporations," the membership of the Project Management Institute, and directories of various federal, state, and local public agencies. Within each organization, a key contact was identified to receive three copies of the questionnaire. In some cases the contact himself was a project manager and was asked to complete one of the questionnaires himself, passing the remaining surveys to two associates within his organization. In those cases where the contact was not a project manager, he was requested to pass along all three questionnaires. Out of a possible 456 respondents, 147 questionnaires were returned completed. An additional 26 questionnaires were returned unanswered, with notes to the effect that the organization did not employ project

Figure 4.1

DEPARTMENT OF CIVIL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139

SURVEY OF PROJECT MANAGERS
IN THE CONSTRUCTION INDUSTRY

This questionnaire is divided into three parts. In the first, you are asked to describe your background, both educational and professional, so that we may identify the career paths which lead to project management positions. The second section asks you to describe in some detail your role as a project manager in the construction industry. The final section asks you to describe what areas of knowledge you feel are important to you as a project manager.

A. Who Are the Project Managers and What Are Their Backgrounds?

1. Your name (optional) _____

2. Your age _____

3. Tabulate your formal educational background:

School	Program	Approximate Dates

4. List the positions you have held previous to the one you now hold: (include previous positions in your present organization)

Title	Type of Employer	Approximate Dates

Figure 4.1

5. Have you participated in any formal or continuing education programs during the last four years? Yes _____ No _____ If yes, describe briefly:

6. Did you enter the construction industry with a view toward becoming a project manager? Yes _____ No _____

7. Is project management your ultimate career objective? Yes _____ No _____ If not, what is your ultimate objective?

8. Does your firm have detailed minimum education and/or experience requirements for individuals occupying project management positions? Yes _____ No _____ If yes, describe briefly:

Figure 4.1

B. Where Are Project Managers and What Do They Do?

1. What is the name of your organization? _____

2. What is the title of your present position? _____

3. What is the title of your immediate supervisor? _____

4. What is the role of your organization? (Check as many roles as are generally applicable. If your present role as a Project Manager involves only one of these, circle that one.)

Owner	Architect
Developer	Engineer
Federal Agency (specify)_____	Contractor
State or Local Agency (specify)_____	Construction Manager
Other (specify) _____	

5. About how many people are employed in your organization? _____

6. About how many project managers are employed in your organization? _____

7. On which of the following types of projects have you acted as Project Manager during the last four years? If possible indicate the approximate number of each type of project.

PROJECT TYPE	NUMBER
Private Construction	
Residential	
Single family	_____
Multi-family	_____
Non-housekeeping (motels, dormitories, etc.)	_____
Industrial	_____
Commercial (including office buildings)	_____
Religious	_____
Educational	_____
Hospital and Institutional	_____
Other Non-residential Buildings (theaters, private transportation terminals. etc.)	_____
Public Utilities	
Railroad	_____
Telephone and Telegraph	_____
Petroleum Pipelines	_____
Electric Light and Power	_____
Gas	_____
Other Private Non-building Construction	_____

Figure 4.1

Public Construction

Housing and Redevelopment	_____
Educational	_____
Industrial (arsenals, shipyards, AEC, etc.)	_____
Hospitals	_____
Other Federal Buildings	_____
Other State and Local Buildings	_____
Highways and Streets	_____
Conservation and Development (Forest Service, Bureau of Reclamation, TVA, U.S. Army Corps of Engineers, etc.)	_____
Sewer Facilities	
Water Supply Facilities	_____
Military Facilities	_____
Other Public Construction (e.g., public mass transit)	_____
	_____

8. How many projects do you usually manage at one time? _____

9. What is the average length of time that you act as manager for a project? _____

10. Describe briefly a typical project which you are now managing or have recently managed:

    Project Type: _____
    Ownership: Private _____ Public _____
    Estimated Total Project Cost: (excluding land) _____
    Estimated Construction Cost: _____
    Estimated Total Project Development Time: _____
    Estimated Construction Time: _____

11. The following is a list of activities associated with the development of different types of projects. No single project contains all of these nor is the list exhaustive. Similarly, no single Project Manager will be involved in all of the listed activities. Based on the project described in B 10. above, place an x in the appropriate spaces for:

    A. Activities in which you perform or participate in the day to day work tasks (gather data, prepare estimates, prepare working documents, make recommendations, etc.), but under the direction and decision authority of others.

    B. Activities in which you not only perform or participate in the day to day work tasks, but for which you also have management responsibility and decision authority.

    C. Activities which you initiate, manage, and/or are responsible for the work of others. You do not, however, perform or participate in the day to day work tasks.

Project Conception and Preliminary Analysis	A	B	C
Conceive project	____	____	____
Prepare project definition	____	____	____
Perform market/demand analysis	____	____	____
Prepare preliminary budget estimates	____	____	____
Evaluate project return on investment	____	____	____

Figure 4.1

	A	B	C
Determine project staging/timing	____	____	____
Determine financing requirements (cash flow)	____	____	____
Determine technical feasibility	____	____	____
Determine socio-political constraints	____	____	____
Determine environmental constraints	____	____	____
Plan, seek and obtain equity participation	____	____	____
Plan, seek and obtain mortgage financing	____	____	____
Plan, seek and obtain construction financing	____	____	____
Obtain legislative funding	____	____	____
Authorize project	____	____	____
Site Acquisition			
Perform location analysis	____	____	____
Select site(s)	____	____	____
Negotiate control of site(s)	____	____	____
Obtain necessary public agency approval of desired site(s)	____	____	____
Obtain local zoning waivers or modifications	____	____	____
Provide relocation assistance	____	____	____
Planning and Design			
Assemble design team	____	____	____
Assemble design-construct team	____	____	____
Define design program requirements	____	____	____
Establish design schedule	____	____	____
Develop conceptual design	____	____	____
Develop detailed design	____	____	____
Prepare design documents	____	____	____
Review and/or approve design documents	____	____	____
Prepare project cost estimates	____	____	____
Coordinate design activities within organization	____	____	____
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)	____	____	____
Prepare environmental impact statement	____	____	____
Conduct public hearings	____	____	____
Obtain regulatory approvals (building permits, etc.)	____	____	____
Contract Award			
Check applicable type:			
_____ Design			
_____ Construction			
_____ Design/Construction			
_____ Other (specify) _____			
Prepare request for bid/proposal	____	____	____
Prepare bid/proposal	____	____	____
Evaluate bid/proposal	____	____	____
Negotiate contract	____	____	____
Award contract	____	____	____
Construction			
Assemble construction team	____	____	____
Schedule construction	____	____	____
Determine construction methods and procedures	____	____	____

Figure 4.1

	A	B	C
Monitor construction costs	____	____	____
Establish inspection/quality control system	____	____	____
Inspect construction			
Daily	____	____	____
Periodic	____	____	____
Establish billable quantities (for cost-plus, unit cost contracts)	____	____	____
Estimate percent completion	____	____	____
Prepare application for progress payment	____	____	____
Approve application for progress payment	____	____	____
Accept completed work	____	____	____
Prepare shop drawings	____	____	____
Approve shop drawings	____	____	____
Purchase construction materials	____	____	____
Hire subcontractors, labor force, equipment	____	____	____
Negotiate change orders	____	____	____
Supervise field construction personnel	____	____	____
Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)	____	____	____
Negotiate labor disputes and/or contracts	____	____	____
Marketing and Use			
Prepare operating (including maintenance) budget	____	____	____
Prepare operating and maintenance schedules	____	____	____
Conduct trial and debugging operations	____	____	____
Direct advertising/promotion campaign	____	____	____
Conduct lease/sale/rent negotiations	____	____	____
Determine space allocation for tenant activities	____	____	____
Purchase and/or install tenant equipment or furnishings	____	____	____
Other Important Activities (specify)			

Figure 4.1

C. What Knowledge and Skills Are Important to a Project Manager?

Listed below are selected project management skills, tools, or areas of concern. On the basis of the scale provided, rank each in terms of its current importance to you in the conduct of your project management responsibilities.

A. Very Important
B. Important
C. Marginal or of no importance

	A	B	C
Understanding overall organization and operation of the construction industry	____	____	____
Project planning and analysis	____	____	____
Financial management	____	____	____
Methods of time and cost control	____	____	____
Interpersonal relations	____	____	____
Labor relations	____	____	____
Marketing	____	____	____
Contracts (preparation, negotiation, etc.)	____	____	____
Other legal factors (e.g., real estate law, zoning)	____	____	____
Management information systems	____	____	____
Proficiency in a particular technical specialty (e.g., foundation engineering, law, accounting) Specify _____	____	____	____
Other factors which you consider very important or important (Please list)			

If you would like us to send you summary results obtained from the questionnaire or further information about our program plans, please fill in your name and mailing address below.

_____ Send questionnaire results

_____ Send further program information

Name _____

Address _____

_____

_____

Table 4.2

Distribution of Questionnaire Responses

Organization Type	Number Responses
Owner	18
Developer	16
Architect	6
Engineer	13
Contractor	18
Design/Construct	22
Public Agency	
Highway	29
Building	17
Heavy Construction	6
Construction Manager	2*
Total	147

* Sample group too small to analyze

managers as such. The survey respondents were divided into nine different groups, in accordance with the role played by the organization employing the participant. Table 4.2 shows the distribution of questionnaire responses.

Analysis of Survey Results

Answers for each of the nine groups were analyzed and summarized, usually in the form of weighted averages for each question. Finally, a composite picture of all project managers in the construction industry was developed.

The analysis of most questions is self-explanatory. Wherever possible, an average response for each group of respondents (in terms of number of years, dollars, etc.) was developed. The analysis of several questions requires further explanation, however.

In question A-3, the project manager was asked to tabulate his formal educational background. The answers to this question were summarized by grouping responses according to the highest degree received by the respondent.

It was usually difficult to generalize a career pattern from the responses given to question A-4. Wherever possible, a description of the career pattern was developed in the text. The most meaningful basis of comparison of the answers to this question was the number of years elapsed between receipt of the

first collegiate degree and attainment of a project management position. A low, average, and high value was determined for each group of participants.

Question B-11 asks the participant to describe his role as project manager by checking off the activities he has performed on a particular project. The activities were grouped according to their place in the life cycle of a project. The following life cycle phases were identified:

Project Conception and Preliminary Analysis,

Site Acquisition,

Planning and Design,

Contract Award,

Construction,

Marketing and Initial Operation.

The respondent was also asked to differentiate between three different types of responsibility for each activity:

A. Activities in which he performs or participates in the day-to-day work tasks, but under the direction of others.

B. Activities in which he not only performs or participates in the day-to-day work activities, but for which he also has management responsibility and decision-making authority.

C. Activities which he manages, initiates, and/or is responsible for the work of others, but does not perform or participate in the day-to-day work tasks.

In order to summarize the answers in a useful manner, two analytical ratios were developed, the response ratio and the responsibility quotient. The response ratio is defined as the ratio of the number of participant responses for a life cycle phase to the maximum possible number of responses in the phase. A participant was considered to have responded once for each activity he checked. If he checked an activity two or more times, indicating several levels of responsibility, this was still counted as one response for that activity. The maximum number of responses for a phase is the product of the number of participants in the organization type and the number of activities listed for the phase. All response ratios were computed and rounded to the nearest 5%. Thus in analyzing the Owner's Project Manager in the Project Conception and Preliminary Analysis Stage, the response ratio is given by:

$$R = \frac{90 \text{ responses}}{18 \text{ participants} \times 15 \text{ questions}}$$

$$= 33\% \approx 35\%$$

The responsibility quotient is defined as the weighted average of the A, B, and C responses. Each response with the level of

responsibility checked as A was given a weight of 1, B a weight of 3, and C a weight of 5. If the participant checked more than one level of responsibility for the same activity, each is counted, unlike the computation for the response ratio. The responsibility quotient is expressed as an integer from 1 to 5. Thus, using the previous example, the responsibility quotient for the section is:

$$R.Q. = \frac{24\ (A) \times 1 + 39\ (B) \times 3 + 27\ (C) \times 5}{24 + 39 + 27}$$

$$= 3.03 \approx 3$$

Extreme care must be taken in interpreting the response ratio and the responsibility quotient. Both are analytical tools and do not imply a precise evaluation of the amount of time spent or importance which the participants place on a particular activity or section of activities. The list of activities is not all-inclusive, nor are the activities necessarily of equal weight in the mind of the respondent and/or the analyst. It is intended that the raw data for each activity provide a measure of the relative importance of different activities - assuming a positive correlation between the frequency of response and the importance of an activity to the participants as a group. The response ratio attempts to accomplish the same purpose for each development phase, assessing relative weights to the participant's involvement in different phases of the project life cycle. Finally, the respon-

sibility quotient provides a measurement of two characteristics of the manager's relationship with an activity or group of activities: 1) the amount of day-to-day participation in the work task, and 2) the amount of managerial responsibility and decision-making authority he assumes for the work. At the low end of the five-point scale, the manager performs most of the work himself and has little responsibility for the work. At the high end of the scale, he delegates most of the day-to-day work to others, but is responsible for the task. The responsibility quotient was considered meaningful primarily in analyzing the level of responsibility and the span of authority on a phase-by-phase comparison, rather than by activity within each phase.

In section C of the questionnaire, the participant is asked to rate each of the skills and/or areas of knowledge listed as:

A. Very Important,

B. Important,

C. Of Little or No Importance.

Again a weighted average was used to evaluate the response to each of the eleven topics. Each A response was given a weight of 3, B a weight of 2, and C a weight of 1. The effect of no response to a particular topic was normalized by giving it no weight in the computations. The eleven topics were ranked on the basis of the weighted averages, number one being the most important.

Table 4.3

Age of Project Managers

(Question A-2)

Organization Type	Age		
	Lowest	Average	Highest
Owner	27	42	55
Developer	26	37	47
Architect	28	39	48
Engineer	36	48	62
Contractor	29	41	57
Design/Construct	31	42	57
Public Agency			
Highway	29	41	59
Building	32	47	55
Heavy Construction	45	53	61

II. Description and Evaluation of Survey Results

A. The Owner's Project Manager

Eighteen of the survey participants classified themselves as the owner's project manager. Their responses are assumed to be typical of those who manage the construction programs of the major industrial, service, and utility companies throughout the United States. Their position is that of an in-house expert and staff advisor to corporate management on the owner's role during the design and construction of capital facilities. In some cases, where the nature of the facility to be built requires detailed knowledge of proprietary information, the owner's project manager may play a role very similar to a project manager for a contractor or designer. He may become very involved in the technical details of the design or construction process. In fact, over 80% of the respondents were located within an engineering or construction division within the organization. The remainder were located within a real estate or special projects division. These men appeared to be acting primarily as contract administrators, reporting to a vice president or general project manager rather than to a chief engineer or building construction manager.

Background

As shown in Table 4.3, the owner's project manager is a relatively young person. The average age of the group is 42 years,

Table 4.4

Degrees Held by Project Managers

(Question A-3)

Highest Degree	Organization Type								
	Owner	Developer	Architect	Engineer	Contractor	Design/ Construct	Highway	Building	Heavy Construction
Associate	2	2		1	3	1	2		
B. Engineering					1	1	1	1	1
BSCE	4	7		7	10	5	22	6	3
MSCE	3	1		3					1
BSEE	2			1	1	2		1	
MSEE									
BSME	2				1	1		3	
MSME						1			
BSChE	3					3			
MSChE	1					5			
BSIE	1	1			1				
MSIE						1			
B. Architecture		1	4						
M. Architecture			1						
M. Urban Design			1						
BBA							1		
MBA		3			1	1			
PhD				1					
LLB						1			
BS Political Science							1		
Agricultural Eng.									1
None		1					2		

Table 4.5

Number of Years Between First College Degree
And First Project Management Position

(Question A-4)

Organization Type	Number of Years		
	Fewest	Average	Highest
Owner	7	16	25
Developer	2	8	17
Architect	0	8	19
Engineer	2	17	32
Contractor	0	11	27
Design/Construct	8	16	32
Public Agency			
Highway	2	12	23
Building	3	13	25
Heavy Construction	12	21	32

Table 4.6

Participation in Continuing Education Programs

(Question A-5)

Organization Type	Participant			Type Program		
	Yes	No	No Response	Technical	Management	Both
Owner	11	7	0	7	4	0
Developer	4	10	2	1	3	0
Architect	1	5	0	0	0	1
Engineer	3	10	0	3	0	0
Contractor	3	15	0	1	2	0
Design/Construct	7	15	0	1	6	0
Public Agency						
Highway	18	11	0	7	7	4
Building	10	7	0	3	6	1
Heavy Construction	6	0	0	0	4	2

Table 4.7

Career Objectives

(Questions A-6, A-7)

Organization Type	Project Management Entering Objective			Project Management Ultimate Objective		
	Yes	No	No Response	Yes	No	No Response
Owner	13	5	0	4	13	1
Developer	11	4	1	1	13	2
Architect	0	6	0	0	6	0
Engineer	5	8	0	4	9	0
Contractor	10	8	0	3	15	0
Design/Construct	11	11	0	3	19	0
Public Agency						
Highway	18	11	0	12	17	0
Building	3	14	0	8	9	0
Heavy Construction	2	4	0	2	4	0

one year below the average age for all participants. All the respondents from this group held engineering degrees, as shown in Table 4.4. Fifty percent had a civil engineering background. The remainder possessed degrees in engineering disciplines related to their employer's line of business. As shown in Table 4.6, 60% of the respondents had also participated in a formal or continuing educational program.

The majority of those questioned entered the industry with a view toward becoming a project manager (Table 4.7). On the other hand, most of the managers did not see project management as being their ultimate career objective. They foresaw future roles in engineering administration or as a department head. They did not appear to see themselves as playing major future roles in the over-all management of the organization (such as President, or Vice President for Production).

The professional backgrounds of the participants were quite similar. Thirteen of the eighteen respondents had worked for the same company continuously. Of the other five, three had worked for only one company other than the one presently employing them. Those who described their professional background in detail in question A-4 listed a succession of progressively more responsible positions within the firm. Most entered the organization as a junior designer, production supervisor, or field engineer. On

Table 4.8

Project Data

(Questions B-9.10,11)

Organization Type	Average Number Projects Managed	Average Time Act As Manager	Average Total Project Cost
Owner	14	2.3yr.	$60M
Developer	2.5	2.0	28
Architect	3	3.0	20
Engineer	3.3	2.1	35
Contractor	1.7	2.1	35
Design/Construct	1.8	2.7	130
Public Agency			
Highway	30	1.6	11
Building	26	2.6	98
Heavy Construction	3.8	4.2	84

the average, it took participants in this group sixteen years after receiving their first degree to reach a project management position (Table 4.5). Almost 75% of the participants listed educational and experience qualifications for project management positions. A minimum of two years of college-level engineering was required; most organizations desired a person with a B.S. in Engineering. There was no clear-cut agreement as to how many years of experience would be required before a person would be promoted to a project management position. Several participants stated that at least 10 to 15 years of related work experience would be required. Others explained that it would be rare within their organization to find a project manager younger than 35. Both statements are consistent with the actual experience of the group. Other requirements cited were plant experience and familiarity with the business and legal aspects of the design and construction of capital facilities.

The Role of the Project Manager

The role of the owner's project manager appears to be primarily that of a technical coordinator and contract administrator for an organization with an extensive building program. As shown in Table 4.8, the average respondent managed 14 projects at one time, considerably above the average. The average length of time he acted as manager for one project was 2.3 years. The partici-

Table 4.9

Response Ratios to Survey Questionnaires

(Question B-11)

	Organization Type								
Development Phase	Owner	Developer	Architect	Engineer	Contractor	Design/ Construct	Highway	Building	Heavy Construction
Conception and Preliminary Analysis	35	60	45	40	10	55	15	40	50
Site Acquisition	30	50	35	25	0	50	5	20	50
Design and Planning	40	65	80	65	5	80	30	45	50
Contract Award	70	70	65	40	25	85	10	45	35
Construction	60	70	35	20	80	80	45	40	25
Marketing and Initial Operation	15	35	5	5	5	20	0	10	20

pants described in detail their role on 10 industrial projects, 6 public utility projects, 2 commercial high-rise complexes, and 1 other non-residential building. All of these projects were privately owned. The average total project cost of these projects was almost $60 million.

As described previously, the participant's detailed analysis of his role on a recent project can be summarized in three different ways - as raw data, as response ratios, and as responsibility quotients. The raw data for the questionnaires returned by this group are included in Appendix B.

The response ratio for the participants during the conception and preliminary analysis stage of the cycle was 35% (Table 4.9). During this early stage of project development, the manager appeared to be primarily concerned with defining the technical constraints and evaluating the feasibility of the project. The manager also prepared preliminary budget estimates for the project. He was not involved in financing the project, or in evaluating the need for the project. As would be suspected from their staff position within the organization, the early role of the owner's project manager is to advise how a facility might be built and how much it might cost to construct.

The response ratio for the owner's project manager was 30% during site acquisition, slightly less than that for the concep-

tion and preliminary analysis stage. Again, the role of the owner's project manager appeared to be more of a technical evaluator than that of an agent for the company. Only four of the eighteen respondents, for example, actually negotiated for control of the site. During the design stage (response ratio 40%), the owner's project manager appeared to act as a scheduler and coordinator of design activities, as an advisor to corporate management with respect to project cost estimates, and as the owner's design approval agent. As the in-house technical representative, he interpreted the owner's requirements to other designers, public agencies, and contractors, and reviewed their work for the owner. As a project manager, he prepared little of the detailed design himself.

The owner's project manager played an important role in the award of contracts for design and/or construction as shown by the response ratio of 70%. The most important activities were the preparation of the request for bid/proposal, evaluating bids and proposals submitted to the company, and negotiating the contracts.

The response ratio during the construction phase of the project was 60%, second only to that for contract award. Although several participants indicated that their firm had in-house construction capability, most (75%) let outside contracts for the construction work. The primary role of the owner's project

manager during the construction phase was that of a contract administrator. The most frequently mentioned tasks were monitoring construction costs, negotiating change orders, approving the contractor's application for progress payment, approving shop drawings, establishing an inspection system, and periodically inspecting the on-site work.

Most of the owner's project managers had little if any role during the marketing and initial operation phase of the development process. (Most buildings were owner-occupied.) Their most frequently cited task was to supervise trial and debugging operations.

The response ratios suggest that the role of the owner's project manager is primarily oriented toward the construction process. From the owner's point of view, the construction phase represents his most substantial investment in a new facility. Thus, the heavy involvement of the project manager in assisting in the contract award and in monitoring the contractor's work would be consistent with this commitment. He may appear to be less involved with many of the tasks associated with the design phase simply because the design activity is more remote and does not involve the magnitude of investment which the construction phase requires.

The responsibility quotients for each phase of the development process provide an insight into how the participants view

Table 4.10

Responsibility Quotients From Survey Questionnaires

(Question B-11)

	Organization Type								
Development Phase	Owner	Developer	Architect	Engineer	Contractor	Design/ Construct	Highway	Building	Heavy Construction
Conception and Preliminary Analysis	3	3	3	4	2	3	3	3	4
Site Acquisition	4	3	3	4	-	3	4	3	5
Design and Planning	4	4	3	4	4	4	4	4	4
Contract Award	3	4	4	4	4	4	4	3	4
Construction	4	3	4	4	4	4	4	4	4
Marketing and Initial Operation	4	4	5	5	5	4	5	4	5

their role as project managers. Based upon the survey results, the owner's project manager displays a responsibility quotient of 3 or 4 for all phases of the development process (Table 4.10). The major implication is that they have managerial responsibility and decision-making authority for most of their tasks. It is more difficult to establish the extent to which the owner's project manager is involved in the day-to-day work tasks. He appears to be most involved in these tasks during the preliminary analysis and contract award stages. This appears to be consistent with the type of tasks which are undertaken during these phases and with the owner's responsibility during each. During the preliminary analysis stage, the owner must evaluate the feasibility of the project and establish alternative methods of developing the project. A relatively broad technical outlook is needed by the owner, and the person who performs the work tasks during this phase should be someone familiar with all phases of project development. During the early stages of project analysis, it may be desirable to restrict the number of people committed to the project, at least until the owner decides to proceed with detailed design. As a result, the project manager is more likely to participate in the day-to-day work tasks of defining and evaluating the project. Again during the contract award phase, it appears necessary to have someone with the project manager's background and

Table 4.11

Important Skills and Areas of Kowledge

(Question C)

	Organization Type								
	Owner	Developer	Architect	Engineer	Contractr	Design/ Construct	Highway	Building	Heavy Construction
Understanding Overall Organization and Operation of Construction Industry	4	2	6	6	3	2	2	1	3
Project Planning and Analysis	1	1	1	1	1	1	4	6	4
Financial Management	7	4	2	8	7	3	7	8	8
Methods of Time and Cost Control	3	3	2	5	3	3	7	4	11
Interpersonal Relations	2	5	6	3	2	5	3	5	2
Labor Relations	8	9	10	9	5	7	10	10	9
Marketing	11	8	8	10	11	11	11	11	9
Contracts	5	6	5	4	5	9	5	3	6
Other Legal Factors	10	7	10	11	9	10	9	6	7
Management Information Systems	6	10	4	7	8	6	6	9	5
Technical Proficiency	9	11	9	2	10	8	1	2	1

experience to ensure that the contract covers all phases of the required work and to evaluate the bids and/or proposals submitted by designers and contractors. It appears likely that both the preliminary analysis and the contract award phases are in-house activities under the direction of the project manager. In the other activities, however, where there are many technical details to be considered and where many of the work tasks may be undertaken by outside personnel, the owner's project manager is not as directly involved in the day-to-day work tasks.

Important Skills and Areas of Knowledge

In the final section of the survey, the participants rated a series of topics on the basis of the importance of each topic to them. Table 4.11 shows the final ranking given to each of the topics by the group of owner's project managers. As one might expect from the response ratio for the conception and preliminary analysis phase, project planning and analysis is an important topic. The participants considered interpersonal relations also to be very important to them, as did many of the participants in other groups. The heavy emphasis upon methods of time and cost control is consistent with the high response ratio for the construction phase and with the high rate of response for activities dealing with the preparation of budget estimates. The lack of emphasis upon marketing is consistent with the role of the owner's project manager.

B. The Developer's Project Manager

Sixteen of the respondents classified themselves as being project managers within a developer's organization. During the development of the questionnaire, it was felt that the response of the owner's and developer's project managers should be very similar. However, there is an obvious difference in emphasis between an owner constructing a project for his own use and a developer who constructs facilities to be used by others. In this section, significant differences between the owner's project manager and the developer's project manager will be established and, where feasible, explained.

Background

Like his owner-counterpart, the developer's project manager is a relatively young person (Table 4.3). The average age of the participants in this group is 37 years. Fifteen of the respondents had at least a two-year engineering degree, and most had completed four years of college (Table 4.4). Twenty-five per cent of the participants had completed work on a master's program. Again, there is a heavy emphasis upon construction education, with 70% of the respondents possessing degrees in building technology, civil engineering, and architecture. Quite different from their owner counterparts, however, are the 25% of the respondents who hold degrees in management. In fact, of the three parti-

cipants who held an MBA degree, only one held an undergraduate degree in engineering. It appears that an engineering education is of lesser importance to the developer's project manager. The professional backgrounds of the participants are quite varied. Sixty per cent had held at least one position as a construction supervisor or manager. Over 50% had been employed by two or more different organizations during their professional career. Thus the developer's project manager appears to be a much more mobile person in terms of his professional career than does the owner's project manager. On the average, the participants in this group reached project management positions within eight years of receiving their first degree (Table 4.5). This was the fastest advancement of any group surveyed. Only 25% of respondents had participated in any formal or continuing education programs (Table 4.6). Again, the majority of the participants entered the industry with a view toward becoming a project manager (Table 4.7). Only one participant saw project management as his ultimate career objective. The others saw themselves eventually in top corporate management positions or as owners of their own development organization. There was little agreement as to detailed qualifications for project management positions. Only 50% of those answering the questions stated that their organization had such requirements. The minimum requirements cited were a general education in building

construction and some unspecified length of construction experience. The most stringent educational requirement noted was for a master's degree in engineering or management. The most stringent professional requirement was that the project manager must be a registered civil engineer. The responses indicated that the number of years of professional experience or of association with the firm were less important considerations than in owner organizations.

The Role of the Project Manager

The sixteen respondents described their role in detail for 10 residential projects, 5 commercial projects, and 1 other non-residential project. On the average, they managed 2.5 projects at one time, each for a period of 2 years (Table 4.8). The average total project cost for the projects described was $28 million.

The response ratio for the conception and preliminary analysis phase was 60%, significantly higher than that found for the owner's project manager (Table 4.9). However, the relative importance of the different tasks within the development phase is not appreciably different from those for owner participants. Tasks associated with financing the project are more frequently cited than in the owner's group, but these activities are still cited with less frequency than the evaluation studies.

The response ratio during the site acquisition phase of

project development was 50%, again a larger response than the phase received from the owner participants. The data showed that the developer's project manager was less frequently involved in obtaining municipal approval than his owner-counterpart.

During the design phase, the developer's project manager was involved in scheduling the design work, reviewing and approving design documents, preparing project cost estimates, and obtaining regulatory approval. Again, the response ratio of 65% is significantly higher than that observed for the owner's project manager, although the ranking in comparison with other phases of the development process is unchanged. The role of the developer's project manager during the design stage appears to be less that of a coordinator than a manager of the design process.

The developer's project manager was frequently involved in the contract award stage, as shown by the high (70%) response ratio for this section. Almost all of the project managers were involved in negotiating the contract for design and/or construction services for their projects, with the actual award of the contract being the second most frequently cited activity. This shows a different emphasis than that of the owner's project manager. The latter is primarily concerned with preparing the request for bid and then evaluating the bids received. The developer's project manager assumes the additional responsibility of nego-

tiating the contract, and is somewhat less involved in the evaluation of proposals, possibly reflecting the less technical background of the managers.

As was the case with the owner's project manager, construction activities are among the most frequently cited tasks with which the developer's project manager must contend. The response ratio for this section was 70%. There is little apparent difference between the roles of the developer's project manager and the owner's project manager during the construction phase. The manager acts primarily as a contract administrator, monitoring construction costs, progressing the work, negotiating change orders, and accepting completed work. They are not involved in the day-to-day supervision or administration of contractor personnel.

Although it was felt that there would be a high rate of response from the developer's project manager in the marketing and initial operation section of the questionnaire, the response ratio of 35% is still very low compared to the group's response in other sections. The response to activities in this section does show an involvement in preparing budgets and schedules for the operation and maintenance of the facility. The project manager is somewhat less involved in promotional and leasing activities.

The responsibility quotients for each phase of the development process again show that as project managers, the participants

assume managerial responsibility and possess decision-making authority for the activities with which they are associated (Table 4.10). The developer's project manager shows more tendency to be involved in the day-to-day work tasks than does his owner-counterpart. It also appears that his day-to-day work tasks are somewhat less technically involved than those of the owner's project manager, with the emphasis being on managing and negotiating rather than on evaluating and coordinating. The responsibility quotients show the developer's project manager to be participating directly in the day-to-day work tasks during preliminary analysis, site acquisition, and construction.

Important Skills and Areas of Knowledge

Table 4.11 shows the ranking given by developer's project managers to the skills and areas of knowledge listed in section C of the questionnaire. Like the owner's project manager, he feels that project planning and analysis is the most important topic. He has downgraded the role of interpersonal relations and replaced it with understanding the over-all organization and operation of the construction industry. Methods of time and cost control placed third in both groups. As might be expected from the response to sections A and B of the questionnaire, the developer's project manager did not consider proficiency in a particular technical specialty to be very important in the conduct of his project management responsibilities.

C. The Architect's Project Manager

Six of the survey participants classified themselves as being an architect's project manager. As a consultant to the owner, the architect has primary responsibility for developing the design for building projects. The architect's project manager has primary responsibility for managing the design process.

Background

As shown in Table 4.3, the average age of the participants in this group was 39, making it one of the youngest groups. As might be expected, all of the participants held degrees in architecture (Table 4.4). Two of the six respondents held master's degrees in the fields of architecture and urban design. Only one of the respondents had taken part in any formal or continuing education programs during the last four years (Table 4.6). The professional background of each manager was quite similar. Each entered the industry as a draftsman or junior designer. Typically this led to design jobs of greater scope and responsibility, such as job captain. This was followed by a period as a project architect and finally as the project manager. It is quite easy to see the progressive professional development of the architect's project manager. The early emphasis is upon developing detailed design skills and upon managing the technical completeness of the design. As the architect matures, he assumes responsibility for developing

the conceptual design. Finally, he assumes the responsibility for the over-all management of the design process. On the average, this advancement took eight years (Table 4.6). Surprisingly, none of the participants entered the construction industry with the intention of becoming a project manager (Table 4.7). All of the respondents saw their ultimate career objective as being something other than project management, either higher management within the firm, partnership, or ownership of their own firm. One person, employed by a large architectural/engineering firm, stated that he would like to become involved in marketing and research. Only two of the respondents felt that well-defined qualifications existed for project management positions. The qualifications which did exist combined an architectural degree or professional registration with technical experience. Other qualities desired were a "record of responsible assignments" and "poise and maturity to deal effectively with a client."

The Role of the Project Manager

Each of the project managers described his role on a recent project. Included were three educational projects, two hospitals, and one transportation terminal. Coincidently, all of the projects were classified as public construction. On the average, the architect's project manager was involved in three projects at any point in time, each for a period of three years (Table 4.8). The

average total development cost of the projects described was over $20 million.

As a consultant to a public agency, each architect felt he had a definite role to play during the conception and preliminary analysis stage of project development. The response ratio for this section was 35%, with over 50% of the participants responding to each of the first ten activities in the section (Table 4.9). The role of the architect's project manager during this time appears to be to first assist the owner to determine the extent and characteristics of his project requirements and then to advise him as to the budgetary and technical requirements for the project. None of the architects played a role in financing the project, although this may in part be due to the public nature of the projects described. In addition, none of the architects felt they played a role in authorizing the project.

The response ratio during the site acquisition phase was 35%, slightly less than that for conception and preliminary analysis. The architect's project manager sometimes assisted in locating and evaluating a site. Most assisted the owner in securing public agency approval of the site selected. The architect did not enter into contract negotiations during site acquisition.

The planning and design phase received the highest response ratio, 80% of all the activities for this group, as might be

expected. In fact, there were only two activities to which less than 50% of the participants responded: assembling the design/construct team, and conducting public hearings. Thus the project manager has a major role both as a designer and as a manager of the design process.

The response ratio during the contract award phase was also quite high - 65%. The data indicate that the project manager assists the owner in preparing the construction contract (probably by writing the technical specifications), and in evaluating, negotiating, and awarding the contract. In addition, the architect's project manager may prepare the bid or proposal for design services to the client.

The response ratio for the architect's project manager during the construction phase was relatively low - 35%. The most frequently cited activities were approving shop drawings and periodically inspecting the construction work. Other activities are primarily housekeeping details under the terms of the contract - informing the owner of the value and quality of the work done to date. The architect usually does not become involved in hiring or supervising field construction personnel, or in purchasing materials. During construction, the architect's project manager plays the role of a knowledgeable observer, advising the client as to what he sees, but not directly involved in the construction process.

The architect's project manager has a very minor role in marketing or equipping a completed facility. Such activity as is performed at this phase is primarily to ensure that the completed facility is operating properly and that the owner knows what he must do in order to keep it that way.

The responsibility quotients show that the architect's project manager is highly involved in the day-to-day work tasks in the early stages of the project's life cycle (Table 4.10). In fact, over 75% of the responses were in the A or B category for the first three sections. The figures also show that the amount of involvement in the day-to-day work tasks drops off considerably during the later stages of project development, until, during marketing and initial operation, none of the architects are involved as anything but managers. Most of the respondents claim to have primary managerial responsibility and decision-making authority for the tasks under their congizance.

Important Skills and Areas of Knowledge

Like the project managers working for the owner and the developer, the architect's project manager feels that a thorough understanding of methods of project planning and analysis is the most important topic listed (Table 4.11). Financial management and methods of time and cost control are other important topics. According to this list therefore, the proper organization and control of a project is of major concern to the architect's project manager.

As might be expected from the role he plays, labor factors and real estate are least important to the architect. Surprisingly, technical proficiency (i.e., architectural competence) was ranked nineth.

D. The Engineer's Project Manager

The thirteen respondents who classified themselves as being project managers for engineering organizations represent some of the largest and most well-known firms in the United States. It is felt that their responses are typical for a manager in a firm whose annual billings is in the multi-million dollar range. Their role is felt to be somewhat different both in scope and complexity from that of the engineer in the small consulting engineering firm who is the project manager de facto, simply because he is the engineer on the job. The latter person may be deeply involved in the management of the project within his firm, but still exercise very little control over the over-all management of the project.

Background

The engineer's project manager, as shown in Table 4.3, is an older person, the average age being 48 years. All of the respondents possessed at least an associates degree in engineering. Over 75% held a degree in civil engineering, with three having attained the masters degree level. Of the remainder, one held a doctorate in chemical engineering and one a bachelors degree in electrical engineering (Table 4.4). Only three of the thirteen respondents

had participated in a formal or continuing education program during the last four years. All of these were technical rather than managerial programs.

The professional background of the participants was quite similar. Most of the respondents began their professional career as a designer or junior engineer, although four were draftsmen during or immediately following college. Many distinguished between the position of project engineer and project manager, similar to the distinction made by the architects between the project architect and the project manager. Four of the respondents indicated that they were associates or partners within the firm as well as being project managers.

Unlike the architects, 40% of the engineers indicated that they entered the industry with the intention of becoming project managers. Only 35% of the respondents saw project management as their ultimate career objective. Several saw themselves becoming partners or owners of engineering firms. Others saw themselves moving into management or engineering administration positions within their present firm. One said his ultimate career objective was to hold "a responsible position on interesting and important projects," implying that the job title is by no means as important as the challenge of the work.

Although almost 50% of the respondents did not think that

their organization had detailed job requirements for project management positions, most all, I think, would agree that an engineering education is almost a universal prerequisite. The least stringent requirements cited were an engineering degree combined with 5 to 7 years of design experience. Another person added that a project manager should be familiar with engineering phases and with construction materials in general. In addition, he should be experienced in estimating job costs and in scheduling both the design and construction phases. Finally, the person should have the ability to get along well with people. The most stringent requirements noted were for a large architectural/ engineering office: 1) be a graduate engineer or architect, 2) be a registered engineer or architect, and 3) be a partner or officer within the company. I feel that most of the respondents would agree with the comments of one of the respondents. There appears to be a path of progressive responsibility leading eventually to the position of project engineer, then to project manager of a small project, and finally to project manager of a large project. The distance a person travels along this path and the time it takes to traverse it are largely a function of the individual's record in previous work tasks.

The Role of the Project Manager

The engineer's project manager, like his counterparts, is unquestionably a very important person within his organization. Two of the participants reported directly to the president of the firm. Seven reported to vice presidents. The remainder reported to division managers or branch heads. The respondents described in detail their role in a variety of facilities, including 6 industrial, 2 power, 2 public transit, 1 commercial, 1 highway, and 1 sewer project. On the average, each respondent managed 3.3 projects at any period in time, each for approximately 2 years. The average development cost for the projects described was $84 million.

The role of the engineer's project manager during conception and preliminary analysis is quite similar to that of the architect. During this early stage of the development process, the project manager assists the owner in defining the project and in preparing budgetary estimates. The respondents indicated little, if any, participation in financing decisions or in evaluating the need for the facility. The engineer's project manager brings to the owner his expertise in design, construction techniques, and construction costs. The response ratio for this section was 40%, a moderately high response for this group.

The response ratio for the site acquisition phase was 25%.

During this time, the engineer's project manager acts as a technical specialist for the owner, performing a location analysis, evaluating alternative sites, and obtaining the approval of the site from various public agencies. Again, like their architect-counterparts, the engineers do not take part in the negotiations to control the site or in any zoning proceedings. These activities presumably are the owner's responsibility.

As might be expected, the primary role of the engineer is in the planning and design phase (response ratio 65%). During this phase, the engineer's project manager assumes responsibility for managing the in-house design activities and for coordinating those activities with organizations outside their firm. Almost all of the managers were responsible for the review and approval of design documents and for the preparation of periodic project cost estimates.

The group of engineer's project managers had a response ratio of 40% in the contract award section of the questionnaire. The most frequently cited activity was evaluating bids and proposals submitted to the owner, usually by a contractor. As the owner's technical expert, and as a person very familiar with the proposed design, the engineer's project manager is in an ideal position to determine the technical adequacy of a contractor's proposal.

In terms of the activities listed, the engineer's project manager has little association with the construction phase. The

response ratio for this section was only 20%. The most frequently cited activity was approval of shop drawings. Other important activities included the periodic inspection of construction, approval of applications for progress payments, acceptance of completed work, and negotiation of change orders. The engineer's project manager does not play a signigicant role in supervising construction personnel.

The response ratio for the marketing and use section for this group was 5%. The engineer's only role in this section appears to be to prepare operating and maintenance schedules and to conduct trial and debugging operations. He does not appear to become involved at all in marketing the completed facility.

Analysis of the responsibility quotients for each section reveals that there are few tasks that the engineer's project manager undertakes for which he does not assume full responsibility and decision-making authority (Table 4.10). Each responsibility quotient was at least level 4. The raw data on the individual responses imply that the respondents are more likely to act as managers than they are to participate in the day-to-day work tasks, particularly during the later phases of project development.

Important Skills and Areas of Knowledge

When asked to evaluate each of the eleven topics in terms of its importance, the group selected project planning and analysis

as most important to them (Table 4.11). Unlike the architects, however, they selected proficiency in a particular technical specialty as being the second most important topic. Other important topics were interpersonal relations and the preparation and negotiation of contracts. Marketing and other legal factors were considered least important to the engineers.

E. The Contractor's Project Manager

Eighteen of the participants were classified as being project managers within contractor organizations. The firms were felt to be representative of regional, national, and international contractors with annual billings in the multi-million dollar range. In smaller companies, the role of the project manager would probably be divided between the officers of the company and the construction field staff.

Background

The average age of the respondents in this group was 41 years. All of the respondents held at least an associates degree (Table 4.4). With the exception of one participant who held a masters degree in business administration, all had an engineering background. Ten of the participants held degrees in civil engineering. Only three of the respondents had participated in any formal or continuing education programs within the past four years. Of these three, one was technical and two were primarily managerial in nature.

Although there were numerous differences in the professional experience of each participant, a relatively distinct career pattern can be defined. Most of the participants entered the construction industry as a field or office engineer for a contractor. Typically, the field engineer would move up to a position as an estimator or project engineer. Fifty-five per cent of the respondents indicated that they had been employed at one time or another as construction superintendents of all or part of a project. There was no clear-cut hierarchy among these three positions, and many of the project managers appeared to move laterally between one or more positions quite often. One respondent indicated that he often worked as an estimator between assignments as a project superintendent. On the average, the participants (55%) entered the construction industry with a view toward becoming project managers. However, 84% of the respondents did not see project management as being their ultimate career objective. This group saw their ultimate position as being in corporate management or with their own business. Several mentioned that they would probably become managers of larger projects.

Only four of the respondents felt that their organization had detailed education and experience requirements for project management positions. Those requirements which were cited generally included a college degree in engineering (preferably civil)

or architecture, and approximately eleven years' field experience. One participant noted that in exceptional cases a craft superintendent or job superintendent with 20 to 25 years' experience might be promoted to project manager.

The Role of the Project Manager

The contractor's project manager is a highly-placed person within the firm. Nine of the eighteen respondents reported to the president or vice president of their firm. The remainder reported to a construction manager or a division manager. On the average, the participants managed 1.7 projects at one time, each for an average of 2.1 years. The managers described in detail their role on a variety of projects, including 2 residential, 2 industrial, 2 educational, 3 hospital and institutional, 2 conservation and development, and a variety of other private and public projects. The average total cost of the projects described was in excess of $35 million.

The role of the contractor's project manager is very well-defined and is restricted almost entirely to the construction phase of the development process. The response ratio for the project conception and preliminary analysis was 10%. Only two of the activities produced any significant responses: preparing preliminary budget estimates and determining project staging and timing. None of the participants played any role in site

acquisition. During the design stage, the only significant activity was the preparation of project cost estimates. The response ratio for this phase was 5%.

It is not until the contract award and construction phases that the contractor's project manager begins to play any significant role. During the contract award phase (response ratio 25%), the most frequently cited activity is negotiation of the contract. Unlike the owners and designers, the contractor's project manager plays a relatively minor role in preparing the request for bid or in the award of a contract. As might be expected, the contractor's project manager played very little role in design contracts.

The response ratio for the construction phase was 80%. In fact, there were only two activities which were cited by less than two-thirds of the respondents - acceptance of completed work and the preparation of shop drawings. Even these two activities had individual response ratios in excess of 50%. The two most frequently cited activities were negotiating change orders and negotiating labor disputes and/or contracts.

The contractor's project manager plays a minor role during marketing and the initial operation of a facility. Of the activities listed, only one - the purchase and/or installation of tenant equipment and furnishings - elicited more than one response. The over-all response ratio for the section was less than 5%.

The responsibility quotients for each section of the questionnaire indicated that the contractor's project manager had managerial responsibility and decision-making authority for most of his activities. In fact, it was only during the early stage of project development - the conception and preliminary analysis stage - when the respondents in this group did not possess managerial responsibility. The responsibility quotient for this section was 2. Significantly, it was only in replying to this section that the participants indicated they performed many of the day-to-day work tasks. This is consistant with the statement of one of the project managers that he acted as an estimator between project assignments.

Important Skills and Areas of Knowledge

The group of contractor-project managers felt that project planning and analysis was the most important topic listed in section C of the questionnaire (Table 4.11). Interpersonal relations, methods of time and cost control, and understanding the over-all organization of the construction industry were also considered to be very important. Proficiency in a technical specialty and marketing were considered the least important topics.

F. The Design/Constructor's Project Manager

Twenty-two project managers emerged from the

survey results - the design/constructor's project manager. This group was not included in the original list of organizational types, but was inferred from the responses to question B-4. The organizations represented by this group included several of the largest engineering and construction firms in the petroleum, industrial, power, and water resources fields.

Background

As shown in Table 4.3, the average age of the twenty-two respondents in this group was 42 years. The educational background of the group was very diverse, reflecting the specialized disciplines associated with each of their clients. As shown in Table 4.4, the respondents held degrees in civil engineering, mechanical engineering, electrical engineering, petroleum engineering, chemical engineering, and industrial engineering, as well as business administration. Six of the respondents held advanced degrees in engineering, management, and law. Almost one-third of the project managers had participated in continuing education programs in the last four years. Six of these programs were management oriented. Several of these programs were sponsored by the employer in conjunction with a local university.

Two different career patterns can be identified as leading to a position as project manager. The first leads the project manager through various engineering positions. Beginning as a

junior design engineer or draftsman, the prospective project manager progresses through various design positions to the post of project engineer, and then to project manager. The second pattern is very similar to that for a contractor's project manager. From the position as field engineer, the future project manager acts as an estimator, resident engineer, and superintendent of construction. On the average, the respondents first reached project management positions sixteen years after receiving their initial degrees.

Only 50% of the participants entered the construction industry with the intention of becoming project managers. Only three of the twenty-two respondents saw project management as their ultimate career objective. The remainder saw themselves either in upper management within their present firm or as owners, builders, or developers. A little more than 55% of the respondents replied that their organizations had minimum education and experience requirements for project management positions. In describing the attributes his firm would look for in a prospective project manager, one participant stated that, in addition to experience and education, a project manager should have demonstrated his capability in handling projects, his ability to get things done, show he can work with and manage people, and show he is a business manager - i.e., that he can handle clients, contracts,

fund expenditures, and can produce profitable projects.

The Role of the Project Manager

The twenty-two project managers for design/construct firms, like their counterparts in engineering and construction, were highly placed within their organizations. They reported to vice presidents, to the manager of projects, manager of engineering, or manager of construction. They described in detail their role on 11 industrial, 5 power, 2 residential, 2 commercial, 1 educational, and 1 military facility. On the average, each project manager was actively involved in 1.8 projects at one time, each for a period of 2.7 years. The average total cost of the projects described was in excess of $130 million, larger than that for any other group.

The activities undertaken by the project manager for a design/construct firm are more extensive than those undertaken by a project manager working for either an engineer or a contractor. Because of the size and complexity of the project, and because of the wider scope of his role, the project manager for the design/construct firm appears to be much more deeply involved in the developmental process than his more specialized counterparts elsewhere in the industry. One might speculate that because one organization controls both the design and the construction process, the project manager may have a more complete perspective from

which to advise the owner. Because one organization will follow the project throughout its development, the owner is able to rely upon the project manager to follow through and coordinate many aspects of the program.

The response ratio for the conception and preliminary analysis phase was 55%. Although this is higher than that observed for a project manager for either an engineer or a contractor, the emphasis is still very much the same. The most frequently cited activities are preparing preliminary budget estimates, determining project staging and timing, and preparing the project definition. Like his engineer and contractor counterparts, the project manager for the design/construct firm had little role in financing decisions.

The response ratio for the site acquisition phase was 50%. again significantly higher than that observed for either the engineer or the contractor groups. During this phase, the project manager is involved in performing a location analysis, selecting a site, and obtaining approval of the site from public agencies involved. The project manager is not normally involved in negotiations for the site.

During the design phase, the project manager is usually involved in most of the activities listed. The response ratio for this section was 80%. The only activity with an individual

response of less than 50% was conducting public hearings.

Most of the project managers were involved in the contract award phase of project development. The response ratio was 85%. The most frequently cited activity was preparing the bid or proposal.

The response ratio for the construction phase was 80%. Again, the respondents indicated that they were involved in almost all of the activities listed. Only one activity received an individual response of 50% or less - daily inspection. The most frequently cited activity was the monitoring of construction costs.

During the marketing and initial operation phase, the project manager is primarily involved in the preparation of operating and maintenance schedules and in the conduct of trial and debugging operations. The response ratio for this phase was 20%.

The responsibility quotients show that the project managers in design/construct firms have decision-making authority and managerial responsibility for most of the activities listed. As shown in Table 4.10, the responsibility quotient was three or four in each section of the questionnaire. The project manager is more involved in the day-to-day work tasks during the early stages of project development - project conception, preliminary analysis, and site acquisition. Presumably, during these early tasks, the project may not have been well-enough defined to warrant a large-scale project organization.

Important Skills and Areas of Knowledge

The group of project managers selected project planning and analysis as the most important topic listed (Table 4.11). Although it did not rate as high as some other topics, several respondents made particular mention of the importance of interpersonal relations:

> The most important aspect to project management is the "people problems." The road to success in project management is handling the people that work for your organization as well as those that work with it. Some of the difficult problems in interpersonal relations is the handling of people with limited ability and excessive desire to move forward. Equally difficult is the person with outstanding ability and little motivation to progress. Each of these require different handling, but if readily recognized, the problem can be solved to the mutual advantage of the individual as well as the contractor.*

Like their counterparts in more specialized engineering and construction firms, the project managers in design/construct firms rated marketing and certain legal factors of little or no importance.

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* From the questionnaire "Survey of Project Managers in the Construction Industry" - W.R. Heinke.

G. The Highway Agency Project Manager

Most highway construction is carried out under the supervision of state and federal highway agencies. The project managers for many of these agencies, however, are somewhat different from their counterparts in private organizations. Of the 29 replies, many were received from chief engineers, area engineers, assistant district engineers, and others who indicated that their responsibility was derived from their posision as a department or division head, rather than from assignment to any particular project.

Background

The average age of the highway agency project manager was 41 years, about one year below the average for all participants (Table 4.3). Although two of the participants had not had any formal education beyond high school, twenty-two held a degree in civil engineering. Over 60% of the participants had taken part in a formal or continuing education program in the past four years. As shown in Table 4.5, seven participated in management programs, seven in technical programs, and four in management and technical programs.

The participants listed two broad patterns of professional employment. The first was construction-oriented, leading from the survey party or field office, through resident engineer, to construction engineer. The second pattern leads from a position as

a junior design engineer or trainee, through the position of project engineer, to that of chief design engineer. It took an average of twelve years for the participants in this group to progress to a level of responsibility above that of the resident engineer for construction or project engineer for design (Table 4.5). Over 60% of the participants entered the construction industry with a view toward becoming a project manager (Table 4.7). Only 40% saw project management as their ultimate career objective. The others generally saw their future in such positions as district engineer, construction engineer, or head of some other department within the highway agency. Several expressed a desire to start their own engineering or construction firm.

All but two of the participants said their agencies had detailed job requirements for project management positions. In most cases, the requirements included several years of experience and/or a civil engineering degree and professional registration. Professional registration was often a prerequisite for advancement to the positions of project engineer and resident engineer.

The Role of the Project Manager

The majority of the participants from public highway agencies were located in construction departments, as shown in Table 4.12.

Table 4.12
Department Affiliation of Public Highway Agency Project Managers

Department	Number
Construction	18
Design	4
Project	4
Planning	3

Most respondents reported to a district or regional supervisor. As mentioned earlier, the project managers in this group were quite unusual in the number of projects they managed. On the average, each respondent managed thirty projects at one time, each for a period of 1.6 years (Table 4.8). This is considerably more projects than was noted for any other group. The average cost of the highway projects described by the participants was $11.4 million.

Because of the large number of participants involved, and because it was a relatively simple matter to distinguish among the different department affiliations, several sets of response ratios were developed: one set each for the planning, project, design, and construction groups, and one for the respondents as a whole.

The response ratios show that the responsibility for different phases of the project development cycle are very much segregated within the different departments of the federal and state highway agencies.

The planning group is primarily concerned with the conception and preliminary analysis of a highway project. The response ratio for this section was 35% (Table 4.9). During this phase, the planners define the project, prepare budgetary estimates, determine a time frame within which a project is to be implemented, and undertake preliminary analysis of the technical, socio-political, and environmental-feasibility of the project. During the site acquisition phase (response ratio 10%), the planning group performs the location analysis and obtains the approval of other public agencies of the selected route. The project managers for the planning group may also be involved in some portions of the design process (response ratio 25%). The questionnaire respondents from this group were not involved in any of the activities listed under contract award, construction, or marketing and initial use.

The design project manager has a different role within a public highway agency. Although his primary function appears to be to manage the design phase, the design project manager is also involved in the preliminary analysis, site acquisition, and

contract award stages of project development. During conception and preliminary analysis (response ratio 35%), the respondents were involved in much the same activities as were the planning group. The primary activity during the site acquisition phase (response ratio 15%) was undertaking the location analysis. The most frequently cited phase was planning and design. The response ratio for this section was 75%. The least frequently cited activities were assembling the design/construct team, obtaining regulatory approvals, and preparing the environmental impact statement. The response ratio for the contract award phase was 25%. None of the design project managers was involved in construction or marketing and initial operation.

Four of the highway agency project managers were within a project department. The response ratios indicate that this group is primarily concerned with the design and construction phases of project development (response ratio 65% and 65%, respectively). This group appears to combine many of the activities of the project managers in design and construction departments. There are obvious advantages found in coordinating the segregated activities with this type of organization.

The final group of highway project managers was located in the construction department. Although they were also involved in other stages, their primary emphasis was on construction. The most fre-

quently cited activities were the periodic inspection of on-site construction, estimating the per cent completion, and approving applications for progress payment. The least frequently cited activities were the purchase of construction materials; hiring subcontractors, labor, and equipment; and preparing shop drawings. The role of the highway construction project manager is clearly that of a contract administrator. In addition to monitoring the construction process, the highway agency construction manager also advises on construction costs, technical feasibility, and on the staging of projects.

An analysis of managerial responsibility and participation in the day-to-day work tasks was made by re-grouping the highway agency project managers. In each phase of the development process, the project manager assumed managerial responsibility and decision-making authority for those activities under his cognizance. Table 4.10 shows the responsibility quotients for each development phase.

Important Skills and Areas of Knowledge

When questioned as a group, the highway project managers ordered the topics in section C of the questionnaire in a quite different manner than their private firm counterparts. The most important topic was proficiency in a particular technical specialty (Table 4.11). This signifies a marked difference between private

and public agencies. Project planning and analysis was ranked fourth, rather than first. Labor relations and marketing were considered to be the least important topics listed.

H. The Public Building Agency Project Manager

Different agencies throughout federal, state, and local governments are charged with the responsibility of overseeing the design, construction, and operation of public buildings. The Public Building Service of the General Services Administration, for example, is responsible for many federal buildings across the country. The Army Corps of Engineers administers the building program for the U.S. Postal Service. School construction on the primary, secondary, and university level is administered by a variety of groups. (See Chapter III, Section VI.) State governments have general services administrations and public building agencies who are responsible for the construction of all state-owned facilities. In some states, quasi-public corporations and authorities have been created to build and operate public facilities (e.g., the Massachusetts Port Authority, the Urban Development Corporation, etc.). The seventeen respondents in this group are felt to be representative of the project managers for public building agencies.

Background

As shown in Table 4.3, the respondents from the public building agencies were one of the oldest groups, with an average age of 47 years. All of the respondents held degrees in engineering or architecture (Table 4.4). Ten of the seventeen managers had participated in a formal or continuing education program within the past four years. Six of these were management programs, three were technical, and one was a combination of management and engineering.

The professional background of the respondents was quite varied. Almost 60% of the participants indicated they had held full-time positions in private industry prior to entering public service. Prior organizations included owners, designers, and contractors. On the average, the respondents reached project management positions within thirteen years of college graduation (Table 4.5). Only 20% of the participants entered the construction industry with a view toward becoming project managers (Table 4.7). Approximately 45% of the respondents saw project management as their ultimate career objective (Table 4.8). Those who felt that they would move on to other positions generally described administrative posts within their agency. Several mentioned that ultimately they would like their own practice. One respondent stated that he would like to move into a teaching or guidance position.

Over 80% of the respondents felt their organization had definite education and experience qualifications for project management positions. These qualifications included an engineering or architectural degree, professional registration, and 2 - 10 years of professional experience.

The Role of the Project Manager

Like their counterparts in the public highway agencies, the public building agency project managers held positions in design or construction departments or in a special project branch (Table 4.13).

Table 4.13
Department Affiliation of Public Building Agency Project Managers

Department	Number
Construction	9
Design	5
Project	3

The respondents managed an average of twenty-six projects at one time, each for a period of 2.6 years (Table 4.8). The average number of projects in this case is somewhat misleading. Only three of the participants managed more than fifteen projects at one time. The median number of projects was ten.

The response ratio for the conception and preliminary analysis phase was 40%. The most significant activities during this phase were the preparation of preliminary budget estimates,

the determination of project staging, and the determination of the technical feasibility of the project. Activities dealing with project financing were the least frequently cited.

The public building agency project manager appears to be less involved in the site acquisition phase (response ratio 20%). The most frequently cited activities were selecting the site, negotiating control of the site, and providing relocation assistance. None of the activities received responses from more than 25% of the participants.

Although less than 30% of the participants were in a design department, the response ratio for the design section of the questionnaire was 45%. During the design phase, the project manager is responsible for the preparation of design documents, for the review and approval of design documents, and for the preparation of project cost estimates.

The response ratio for the contract award section of the questionnaire was 45%. The most frequently cited activity was evaluating the bids or proposals submitted to the agency, although there was little difference in the level of response for different activities within this section.

The response ratio for the construction phase of project development was 40% The most frequently cited activity was monitoring construction costs. Other important activities were

scheduling construction, approving the contractor's application for progress payment, and accepting completed work. Each of the above activities were mentioned by more than 70% of the respondents in this group. Based upon the response to the questions in this section, it is apparent that the public building agency project manager is primarily a contract administrator during construction, rather than a construction supervisor.

As would be expected for a public agency, the respondents were not involved in advertising or leasing arrangements for their buildings. The response ratio for the marketing and initial operation section of the questionnaire was 10%. The activities cited included preparation of operating and maintenance schedules and the purchase of equipment and furnishings.

The responsibility quotients (Table 4.10) show that the project managers often participate in the day-to-day work tasks. The responses show a high degree of day-to-day participation in conception and preliminary analysis, site acquisitions, and contract award. The participants are more likely to supervise the work of others during design, construction, marketing, and initial operation. The project managers have responsibility and decision-making authority in all phases of project development. The participants lacked responsibility and decision-making authority in only two of the activities listed: conceiving and authorizing the project.

Important Skills and Areas of Knowledge

As was noted for the highway agency project managers, the public building agency participants downgraded the importance of project planning and analysis. The most important topic listed was understanding the over-all organization and operation of the construction industry (Table 4.11). Other highly-ranked topics were proficiency in a particular technical specialty and understanding contracts. The least important topics, as would be expected, were labor relations and marketing.

I. The Project Manager for Public Heavy Construction

There are many non-building projects carried out under the supervision of federal, state, and local agencies. In addition to the highway projects described previously, this type of construction includes major power and conservation projects such as those sponsored by the Bureau of Reclamation and the Tennessee Valley Authority, navigation and flood control projects under the cognizance of the U.S. Army Corps of Engineers, sewer systems, and water supply systems. This group of project managers is assumed to be typical of those who supervise the development process for public heavy construction.

Background

Six of the respondents may be classified as project managers for public heavy construction. As shown in Table 4.3, this was the

oldest group in the survey. The average age of the participants was 53 years. Almost 70% of the respondents held degrees in civil engineering (Table 4.4). One held a degree in agricultural engineering. All of the respondents had participated in a formal or continuing education program in the past four years. As shown in Table 4.6, four respondents took part in programs which were primarily managerial in nature, while the remaining two participated in programs in both management and engineering.

Most of the respondents in this group had design backgrounds, entering the industry as junior engineers. Advancement was similar to that noted for other engineering agencies, showing progressive responsibility to the position of project engineer and, finally, to project manager. On the average, the participants reached project management positions within twenty-one years of receiving their undergraduate degrees, far above the average for the survey (Table 4.5). Only 35% of the respondents entered the construction industry intending to become project managers, as shown in Table 4.7. Thirty-five per cent of the participants saw project management as their ultimate career objective. The remainder saw future positions in management or engineering administration for their present agency.

Almost 85% of the participants felt their organizations had detailed education and experience requirements for project

management positions. These included an engineering degree, related experience, and as much as eighty classroom hours of management training.

The Role of the Project Manager

Five of the six respondents were located in federal agencies. The sixth was employed by a regional commission charged with the responsibility of constructing and operating regional highways and recreational facilities, as well as the central water and sewer distribution systems. As shown in Table 4.8, the participants managed an average of 3.8 projects at one time, each for an average of 4.2 years. The relatively long project length may in part be explained by the fact that heavy construction projects are, by their nature, more lengthy than most building projects. The average cost of the projects described was $83.6 million.

The response ratio for the conception and preliminary analysis phase was 50%. During this time, the project manager supervised a technical and economic analysis of the project to determine its physical characteristics and feasibility. In this case, 50% of the respondents were involved in obtaining legislative funding for the project.

The respondents gave very consistent responses for the site acquisition phase of project development. The response ratio for each question within the section was 50%. The respondents appeared

to answer the questions in this section in a block, selecting either all or none of the activities.

The response ratio for the design and planning section of the questionnaire was also 50%. The most frequently cited activities were reviewing design documents, preparing project cost estimates, coordinating design activities, preparing the environmental impact statement, and conducting public hearings. Each of these activities was selected by over 65% of the participants.

The participants were somewhat less involved in the later phases of project development. The response ratio for the contract award phase was 35%. The most frequently cited activity was evaluating the bids and proposals submitted by design and construction agents.

The response ratio for the construction phase was only 25%. Only one of the activities - accepting completed work - was mentioned by more than 50% of the respondents. Other important activities included scheduling construction, periodic inspection of construction, and negotiating change orders.

Although the response ratio of 20% for the marketing and initial operation phase was low for this group, the response was quite high compared to other types of project managers. The project manager is involved in supervising the preparation of operation and maintenance schedules and in debugging operations.

The responsibility quotients for the different sections of the questionnaire were very high (Table 4.10). The responsibility quotient of 5 for the site acquisition and initial operation phases indicates little, if any, involvement in the day-to-day work tasks and complete managerial responsibility. The responsibility quotient for each of the other phases was 4. During these phases, the project managers were more likely to take part in the day-to-day work tasks.

Important Skills and Areas of Knowledge

The project managers for public agencies dealing with heavy construction projects also rated proficiency in a technical specialty as being very important. As shown in Table 4.11, this group, like their other public agency counterparts, downgraded somewhat the importance of project planning and control as seen in private firms. Surprisingly, the group ranked methods of time and cost control as least important of the topics listed.

III. The Project Manager in the Construction Industry

A composite picture of the project manager was developed from the questionnaire responses. By grouping together all of the responses, generalizations as to the educational and professional background, role, and important skills and areas of knowledge can be made.

Table 4.14

Composite Project Manager

(Questions A-2,4, B-8,9, & 10)

Topic	Response Low	Response Average	Response High
Age (Years)	26	44	62
Years to First Project Management Position	0	14	32
Number Projects Managed	1	9.5	300
Length Time Act As Manager (Years)	1	2.5	8
Total Project Cost	$100,000	$61.1 M	$750 M

Background

There is no one background which is characteristic of all project managers. The average age of all respondents was 44 years (Table 4.14). However, the ages ranged from a low of 26 to a high of 62 years. As shown in Table 4.15, the overwhelming majority of all respondents held degrees in engineering - including 50% with degrees in civil engineering. Only 2% had not received at least a two-year college degree, and 17% held postgraduate degrees.

Table 4.15
Educational Background of Project Managers

Degree	Per Cent Respondents
Civil Engineering	50
Other Engineering	33
Architecture	9
Management	4
High School	2
Other	2
Postgraduate*	17

(* included in above categories)

Almost half of the respondents had continued their formal education within the past four years (Table 4.16). The majority of the courses taken were managerial in nature.

In general, the project managers entered the construction industry as design engineers or as construction field staff personnel. Future positions emphasize development of a technical

Table 4.16

Composite Project Manager

(Questions A-5,6,7)

Topic	Percent Response
Continuing Education	
Yes	45
No	55
Type Program	
Management	35
Technical	50
Both	15
Entering Career Objective	
Yes	50
No	50
Ultimate Career Objective	
Yes	25
No	75

expertise, usually related to the design or construction phases of project development, management of the technical details of a project, and, finally, management of the business details of the project. Thus the project manager emerges as a technical "expert" who manages an aspect of the business of building a facility. On the average, the respondents to the questionnaire first reached project management positions 14 years after receiving their undergraduate degrees (Table 4.14). A wide range of responses was received, however. A few respondents had already reached project management positions before receiving an undergraduate degree. On the other hand, at least three of the participants first reached project management positions 32 years after receiving their first college degree. As shown in Table 4.16, approximately half of the respondents entered the construction industry intending to become project managers. The majority of the respondents had ultimate career objectives other than project management. Although some stated that they expected to move on to bigger and more complex projects, most of the respondents were seeking positions where they could be managing the project managers. Many stated that they would like to own a development, design, or construction firm. This was more often cited by managers within private organizations than by those within public agencies.

Detailed professional and educational requirements existed for project management positions within many organizations, particularly for public agencies. Although most organizations required completion of a two- or four-year technical program, some, particularly public agencies, permitted the substitution of professional experience for college preparation. Most of the respondents cited a record of progressive responsibility, rather than a specific number of years experience, as being a prerequisite for a project management position. Professional registration was mentioned by many as being a necessary qualification.

The Role of the Project Manager

The respondents to the survey had been involved in virtually every type of private and public construction project listed. On the average, the respondents managed 9.5 projects at one time (Table 4.14). The median value was somewhat lower - 3.8 projects. Project managers for private owners, public highway agencies, and public building agencies managed considerably more projects than average, implying that these respondents were administrative managers, rather than project managers in the strictest sense of the word. On the average, the respondents acted as manager for 2.5 years on each project (Table 4.14). The average total development cost of the projects described in detail by the respondents was $61 million (Table 4.14). As can be seen from the table, there

Table 4.17

Composite Project Manager

(Question B-11)

Development Phase	Response Ratio	Responsibility Quotient
Conception and Preliminary Analysis	35%	3
Site Acquisition	25	3
Planning and Design	50	4
Contract Award	50	4
Construction	55	4
Marketing and Initial Operation	15	4

was considerable range in the project development cost, and many respondents described projects valued in excess of $100 million.

The response ratio and responsibility quotient for each phase of the development process were determined and are summarized in Table 4.17. Determining the aggregate responses for each phase was not considered to be as meaningful in analyzing the composite project manager as examining the responses to the individual activities within each phase. Conclusions can then be drawn, relating the activities listed in question B-11 and the skills and areas of knowledge listed under section C of the questionnaire.

During project conception and preliminary analysis, the primary role of a project manager in the construction industry is to determine the project staging and timing and to prepare preliminary budget estimates. Over 60% of the respondents stated that they participated in these two activities. The project manager was usually involved in the day-to-day work tasks associated with preparing a preliminary schedule. He usually acted as a manager rather than a participant in preparing preliminary budget estimates. Almost 50% of the participants stated that they were also involved in conceiving the project, defining the project, and evaluating the technical feasibility and environmental impact of the project. Most of the respondents participated in the day-to-day work tasks associated with these activities.

Very few of the project managers were involved in acquiring a site. The most frequently cited activities were performing a location analysis and obtaining public agency approval of desired sites. Many of the managers also selected the site. Approximately 30% of the respondents participated in these site acquisition activities.

Over 60% of the respondents participated in the preparation of project cost estimates and in the review and approval of design documents during the planning and design phase. In both cases, the respondents managed the activities rather than participated in the day-to-day work tasks. Other activities cited by more than 50% of the participants included: coordination of design activities within and outside the organization, establishment of a design schedule, definition of design program requirements, and assembling the design team. In each of these activities, the respondents usually participated in the day-to-day work tasks.

There was very little difference between the number of responses for each of the activities listed under the contract award phase of project development. The two most frequently cited activities were evaluating a bid or proposal and negotiating the contract. Each received a response from approximately 50% of the participants.

The two most frequently cited activities during the construction phase included negotiation of change orders and monitoring construction costs. These activities were performed by approximately 75% of the participants. Only six of the twenty activities were selected by less than 50% of the respondents: preparation of shop drawings; purchase of construction materials; negotiation of labor disputes and contracts; hiring subcontractors, labor, and equipment; field personnel administration; and daily inspection of on-site construction. At least 30% of the respondents performed all of the activities listed. The over-all responsibility quotient for the construction phase was 4, indicating that the respondents assumed managerial responsibility for the activities in this phase and did not usually participate in the day-to-day work tasks.

Few of the project managers were involved in any of the activities listed under marketing and initial operation. As shown in Table 4.17, the response ratio for this phase was only 15%. The most frequently cited activities were the preparation of operating and maintenance schedules, the conduct of trial and debugging operations, and the preparation of the operating budget. None of the activities listed was cited by more than 25% of the respondents. In each case, the respondents had managerial responsibility for the activities and acted primarily as managers, rather than as participants in the day-to-day work tasks.

Table 4.18

Composite Project Manager

(Question C)

Rank	Skill or Area of Knowledge
1	Project planning and analysis
2	Understanding overall organization and operation of the construction industry
3	Interpersonal relations
4	Methods of time and cost control
5	Contracts
6	Technical proficiency
7	Financial management
8	Management information systems
9	Labor relations
10	Other legal factors
11	Marketing

Important Skills and Areas of Knowledge

Table 4.18 shows the relative importance assigned by the respondents to the various topics listed in section C of the survey. The most important topic to a project manager is project planning and analysis. These skills are used to determine project staging, to perform the location analysis, to define the design program requirements, to establish inspection and quality control systems, and to prepare operating and maintenance schedules - to name a few activities. Understanding the over-all organization and operation of the construction industry was rated the second most important topic. This knowledge would be useful to a manager who is attempting to define a project, seeking public agency approval of sites or design documents, or coordinating design and construction activities. As can be seen from the responsibility quotients, in many activities the project manager must depend upon the efforts of others to accomplish the day-to-day work tasks. This would explain the high ranking given to interpersonal relations. Methods of time and cost control were ranked fourth of the eleven topics. Scheduling and estimating are major activities during the conception and preliminary analysis, planning and design, contract award, construction, and marketing and initial operation phases of project development. The high response ratio given to the contract award phase is evidenced by the fifth place

rank of a knowledge of contracts and the skills involved in preparing and negotiating contracts. Although rated sixth most important, many of the project manager's major activities depend upon a proficiency in a technical specialty. During preliminary analysis, the project manager is often asked to evaluate the technical feasibility of a project, an activity in which the manager frequently participated in the day-to-day work tasks. Although the manager does not necessarily develop the design or design documents, he frequently must review and/or approve them. The preparation and evaluation of a bid or proposal requires an expertise in construction methods and procedures. During construction the project manager also must inspect and accept the on-site work as meeting the standards set forth in the specifications. In fact, the sixth place rank of this topic is surprisingly low when one considers how many of the activities depend upon the technical proficiency of the project manager.

The remaining topics are associated with less frequently cited activities during project development. Each of the topics, while an area of possible concern to the project manager, is more closely related to a specialist within the organization. As such, the remaining topics often are not absolutely necessary to the project manager in the conduct of his management responsibilities.

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Appendix A

Types of Construction Projects

Appendix A*

NEW CONSTRUCTION

New construction, for purposes of this series, is defined as the initial erection of and improvements to immobile structures or service facilities. This includes:

1. Erection of the new structure.

2. Mechanical installations—Plumbing, heating, electrical work, elevators, escalators, central air conditioning, and other similar building services.

3. Additions and alterations—Includes such items as additions of a wing or one or more floors to an existing building, conversion of space to other uses or the installation of service facilities such as elevators or central air conditioning to an existing building.

4. Outside construction—Fixed structures or facilities such as sidewalks, highways and streets, roadways, parking lots, utility connections, outdoor lighting, landscaping, railroad tracks, air fields, piers, wharves and docks, telephone and telegraph lines, radio and television towers, water supply lines, sewers, water and signal towers, electric light and power distribution and transmission lines, petroleum and gas pipelines and distribution lines, and similar facilities which are built into or fixed to the land.

5. Installation of the following specific items:

Boilers	Refrigeration systems
Overhead traveling cranes	Blast furnaces
Brick kilns or coke ovens	Open-hearth furnaces

6. Erection of all fixed, largely site fabricated equipment which is not housed in a building, such as petroleum refinery and comparable chemical plant structures.

7. Land development—Clearing and grading of undeveloped land; installation of facilities such as public-use streets, sidewalks and curbs, sewer and water mains, and gas mains.

8. Also included are the structural changes to a building which are necessary for the installation of equipment items which are not considered construction.

The following types of activities are EXCLUDED from new construction:

1. Maintenance and repairs to existing structures or service facilities (e.g., repapering, repainting, reroofing, street and highway patching).

2. All machinery and equipment items not specifically covered above, such as heavy industrial machinery, printing presses, stamping machines, bottling machines, and packaging machines; also special purpose equipment designed to prepare the structure for a specific use, such as steamtables in restaurants, pews in churches, lockers in school buildings, beds or X-ray machines in hospitals, and display cases and shelving in stores.

3. Drilling of gas and oil wells, including erection of off-shore drilling platforms; digging and shoring of mines; work which is an integral part of farming operations such as plowing, terracing and digging of drainage ditches.

VALUE OF NEW CONSTRUCTION PUT IN PLACE

The "value of construction put in place" is a measure of the value of construction installed or erected at the site during a given period. For an individual project, this includes the cost of material installed or erected, the cost of labor performed (both by the contractors and by force account employees) and a proportionate share of the cost of construction equipment used, the contractor's profit, the project owner's overhead costs, the cost of architectural and engineering work and miscellaneous costs chargeable to the project on the owner's books.

The total value in place for a given period is the sum of the value put in place on all projects underway during this period, regardless of when work on each individual project was started or when payment was made to the contractors.

The estimates do not always conform completely to the value-in-place concept. For some categories, the published estimates represent payments made during a period rather than the value of work actually done during that period. For other categories, the estimates are derived by distributing the total construction cost of the project in accordance with fixed construction progress patterns.

While the inability to adhere strictly to the concept of value in place may affect the interpretation of monthly or quarterly trends and expenditures, it is believed that the annual estimates are more reliable.

CLASSIFICATION OF CONSTRUCTION

The descriptions which follow set forth the general principles used in classifying construction projects. Two broad groupings are presented—projects which are privately owned and projects which are publicly owned. The distinction between publicly owned and privately owned construction is made on the basis of ownership of project during the construction period.

CLASSIFICATION OF PRIVATE CONSTRUCTION

Residential Buildings—Farm and Nonfarm

New Housing Units. Includes all new houses and apartments. This category includes housing at all levels

* Construction Reports - Series C30-70S - Value of New Construction Put In Place, 1958-1970, Department of Commerce, (Washington, 1971), pp. 63-66.

of value and quality, such as prefabricated units, shell houses, basement (or capped) houses, and houses built of used materials.

The classification excludes group quarters, transient accommodations and residential units in buildings which are primarily nonresidential. It excludes new units provided by conversion of residential or nonresidential space to additional housing units. It also excludes mobile homes, house trailers, or houseboats.

Residential Additions and Alterations. Includes all remodeling of or additions to housing units subsequent to their original completion. It also includes the construction of additional housing units in existing residential structures, the finishing of basements or attics, and the modernization of kitchens, bathrooms, etc. Work representing normal maintenance and repair is not included.

Nonhousekeeping Residential. Includes fixed structures providing residential facilities other than housekeeping units. These can be generally characterized as nonhousekeeping quarters, i.e., hotels (other than apartment hotels), motels, dormitories, nurses' homes, etc.

Nonresidential Buildings

Includes industrial, commercial, religious, educational, and hospital and institutional buildings and nonresidential auxiliary facilities. These auxiliary facilities include warehouses, restaurants, office buildings, power plants, recreational facilities, parking lots, streets, sidewalks, sewer and water facilities, railroad sidings, docking facilities, stadiums, etc.

The commercial category also includes nonresidential auxiliary facilities which are intended to serve the commercial building under construction. These are primarily parking lots, streets, sidewalks, sewer and water facilities, etc.

Industrial. Includes all buildings and structures at industrial establishments, as defined in major groups 19 to 39 of the Standard Industrial Classification Manual.[1] Warehouses owned by and constructed for the exclusive use of one or more industrial establishments are classified as industrial even when not located at the site of an industrial establishment. Office buildings owned by industrial companies but not constructed at the site of an industrial establishment are classified as commercial.

Commercial. Includes (a) all office buildings, including professional office buildings, which are used primarily for rental of office space (except office buildings at industrial sites which are classified industrial) or to house banks and other financial institutions, except those built by public utilities[2] for their own use; (b) all warehouses and storage buildings, including cold storage plants, grain elevators and silos, except where such facilities are at an industrial establishment or owned and used exclusively by one or more industrial establishments; (c) all buildings and structures which are intended for use in the wholesale, retail, or service trades. Complete shopping centers, department stores, drug stores, parking garages, auto service stations and repair garages, beauty schools, barber schools and dance schools are included in this category. An office building owned by an industrial company but not located at an industrial establishment is also classified as commercial. Auxiliary facilities at an establishment belonging to one of the other nonresidential buildings categories are excluded.

Religious. Includes all buildings and structures at religious establishments, as defined in industry group 8661 of the Standard Industrial Classification Manual. Buildings and structures at other establishments maintained by religious organizations, such as educational or charitable institutions, hospitals, and publishing houses are not included in this category.

Educational. Includes all buildings and structures, except housing (dormitories and family housing), at educational establishments, as defined in major group 82 of the Standard Industrial Classification Manual. Also includes museums, art galleries and other establishments defined in major group 84. Beauty schools, barber schools and dancing schools are classified as commercial.

Hospital and Institutional. Includes all buildings and structures at hospitals, as defined in industry group 8061 of the Standard Industrial Classification Manual, except housing for nurses and doctors. Also includes sanatoria, convalescent and rest homes, homes for the aged, nursing homes, orphan asylums and similar establishments for prolonged institutional care. Clinics with surgical or outpatient facilities are also part of this category.

Note: Buildings which are primarily for doctors' offices but include some testing facilities are classified as commercial even though they may be known as clinics.

Miscellaneous Nonresidential Buildings. Includes all nonresidential buildings which are not classified in the industrial, commercial, religious, educational, or hospital and institutional categories, except farm buildings and buildings owned by public utility companies. Structures other than buildings are excluded unless they are auxiliary facilities for a building that falls into this category. For example, a parking lot built as part of a

[1] Standard Industrial Classification Manual, 1967 Edition; prepared by the Executive Office of the President, Bureau of the Budget.

[2] Telephone and telegraph companies, railroads, electric light and power companies, gas companies and petroleum pipeline companies.

new theater project would be included but a parking lot built independently would not be included. Buildings used as motion picture studios or theaters or in providing amusement and recreation services—SIC industry groups 7811, 7831, and major group 79—are included. Also includes radio and television stations, bus and airline terminal buildings and animal hospitals.

Farm Construction—Excluding Housing

Includes buildings and structures such as barns, storage houses, smoke houses, wells, fences, etc., which are constructed on places classified as farms according to the definition used for the 1960 and 1970 Census of Population and Housing.

Public Utilities

For each of the public utility categories, construction expenditures are compiled on an industry basis rather than by type of building or structure. Thus, for each of the following kinds of privately owned companies or cooperatives, all construction expenditures are grouped together:

Railroad	Petroleum pipeline
Telephone	Electric light and power
Telegraph	Gas (manufacturing, transmission and distribution)

In general, each category includes all construction for that category. Hence, the estimates include not only the type of construction peculiar to the operation of the type of utility, but also other types of nonresidential building and nonbuilding construction built by these companies for their own use, such as office buildings.

All Other Private

Includes all privately owned projects which are not elsewhere classified such as streets and bridges, dams and reservoirs (not constructed by public utility companies), sewer and water facilities, parks and playgrounds, airfields, etc.

CLASSIFICATION OF PUBLIC CONSTRUCTION

Public construction is composed of two components, State and local construction and Federal construction. The systems of classification for these two components differ in many respects. The following discussion provides a generalized description of the system of classification applicable to State and local construction and Federal construction.

State and Local Construction

The estimates for State and local construction are based on data compiled by the Census Bureau in a monthly Survey of Construction Expenditures by State and Local Governments. Monthly reports are obtained from all State governments and a sample of local governments and governmental agencies. Where the reporting agency has jurisdiction over a single function (highway department, school district, waterboard) all expenditures reported by that agency are classified according to that function. Where the reporting agency has jurisdiction over more than one function, the agency is requested to report separate expenditure totals for each function. Separate data are compiled in the survey for the various functions represented by the 17 categories of State and local government expenditures, and these are combined into the 9 value-in-place categories. The 17 expenditure categories and the 9 comparable value-in-place categories are:

Value in Place	State and Local Government Expenditures
Housing and Redevelopment	Housing and Redevelopment
Educational	Educational
Hospital	Hospital
Other State and Local Buildings	Fire Protection Police Protection Correction Parks and Recreational Facilities General Purpose Buildings All Other State and Local Buildings
Highways and Streets	Highways and Streets
Conservation and Development	Natural Resources
Sewer Systems	Sewer Systems
Water Supply Facilities	Water Supply Facilities
Miscellaneous State and Local Construction	Airports Electric Light and Power Water Transport and Terminals Transit

Federal Construction

The value-in-place estimates for Federal construction are classified into nine separate categories, which are defined below.

Residential. Includes new family housing units constructed for the armed services and the rehabilitation of

existing military family housing units. However, military barracks and bachelor officers' quarters as well as family housing for Coast Guard personnel are classified under "Military facilities." Housing for forest rangers and national park employees is classified under "Conservation and Development."

Industrial. Includes manufacturing, assembling and processing buildings and their related facilities such as arsenals, ordnance works and shipyards. Also includes all construction by the Atomic Energy Commission.

Educational. Includes primary, secondary, college and university level educational buildings; laboratories and science buildings; libraries, art galleries and museums. Educational facilities provided by the Department of Defense for its personnel are included under "Military facilities." Federally owned schools on Indian reservations are included under "Other Federal buildings."

Hospitals. Includes general, mental, tuberculosis and chronic disease hospitals; veterans' hospitals and domiciliaries; clinics and infirmaries. Federally owned hospitals on Indian reservations are included under "Other Federal buildings."

Other Federal Buildings. Includes general office buildings, customhouses, courthouses, jails and penitentiaries, except buildings (other than Soldiers' Home) owned by the Department of Defense. Also includes all projects under the jurisdiction of the following Federal agencies:

Department of Commerce, National Bureau of Standards
Department of Defense, U.S. Soldiers' Home
Department of Health, Education, and Welfare, Indian Health Service
Department of Interior, Bureau of Indian Affairs
Department of Interior, Bureau of Mines
Department of Interior, Geological Survey
National Aeronautics and Space Administration
National Science Foundation

Military Facilities. With the specific exceptions noted below, this category covers all construction owned by the Department of Defense. It also covers construction of Coast Guard facilities. The category includes troop housing, administration and training buildings, warehouses, mess halls, recreation centers, educational facilities, airfields and airport buildings, missile sites, etc.

The following specific types of construction owned by the Department of Defense are classified in the categories indicated in the parenthesis:

Family housing for the armed Services (Residential)
Civil Works—Construction by Corps of Engineers (Conservation and development)
Department of Defense owned industrial facilities (Industrial)
Military hospitals (Hospitals)
Soldiers' Homes (Other Federal buildings)

Highways. Includes streets, bridges, vehicular tunnels, viaducts and forest and park roads owned by Federal agencies, other than Department of Defense. Also includes the following items if built in connection with a Federal road: culverts, right-of-way drainage, erosion control, lighting, guard rails and earthwork protective structures.

Conservation and Development. Federally owned construction for the following agencies is classified into this category:

Department of Agriculture, Forest Service
Department of Agriculture, Soil Conservation Service
Department of Defense, Army Corps of Engineers—Civil Works
Department of Interior, Bonneville Power Administration
Department of Interior, Bureau of Indian Affairs
Department of Interior, Bureau of Reclamation
Department of Interior, National Park Service
Department of Interior, Office of Saline Water
Department of Interior, Southwestern Power Administration
Department of State, International Boundary and Water Commission, U.S. and Mexico
Department of Transportation, St. Lawrence Seaway Development Corporation
Tennessee Valley Authority

Miscellaneous Federal Construction. Includes all Federally owned construction work not elsewhere classified.

Types of Construction Projects*

Building Construction

Single-Family Houses - Includes single-family homes, town houses, and row houses.

Multifamily Residential Buildings - Includes houses for two or more families, apartment houses, etc.

Other Residential Buildings - Includes hotels, motels, dormitories, nurses' homes, and other nonhousekeeping residential structures.

Industrial Buildings and Warehouses - Includes all industrial buildings and plants which are used to house the production, assembly, and warehousing activities of those establishments. Commercial warehouses, cold storage plants, grain elevators, and storage buildings are also included here.

Office and Bank Buildings - Includes all buildings which are used primarily for office space or to house banks and other financial institutions. It also includes government administrative buildings.

Stores, Restaurants, Public Garages, and Auto Service Stations - Includes all buildings which are intended for use primarily in the wholesale, retail, and service trades. For example, complete shopping centers, department stores, drug stores, restaurants, public garages, and auto service stations are in this category.

Religious Buildings - Includes all buildings which are intended for religious services and functions, such as churches, synagogues, convents, monasteries, seminaries, etc.

Educational Buildings - Includes all buildings which are used directly in the administrative and instructional activities of establishments furnishing formal academic or technical courses. These establishments include colleges and universities as well as elementary and secondary schools, and correspondence, commercial, and trade schools. Libraries, museums, and art galleries, as well as laboratories which are not a part of a manufacturing establishment, are also included as educational.

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* 1967 Census of Construction Industries, Vol. 1, Department of Commerce, Bureau of the Census (Washington, 1971), p. A-4.

Hospital and Institutional Buildings - Includes all buildings which are primarily engaged in providing hospital and institutional care, such as general, mental, or tuberculosis hospitals, clinics or infirmaries and sanitariums, and such institutions as nursing homes, homes for the aged, orphanages, etc.

Amusement, Social, and Recreational Buildings - Includes buildings which are used primarily for entertainment, social and recreational activities, such as sports arenas, theaters, music halls, golf and country club buildings, fraternal organizations, lodges, skating rinks, bowling alleys, and indoor swimming pools, etc.

Other Nonresidential Buildings - Includes buildings which are not classified elsewhere, such as fire stations, bus and air passenger terminals, and hangars, etc.

Nonbuilding Construction

Highways and Streets - Includes streets, roads, alleys, sidewalks, curbs and gutters, and forest and park roads. Also includes - in connection with highway and street construction - erosion control, new and extension of old culverts, right-of-way drainage, lighting, fences, highway signs and guard rails, and earthwork protective structures.

Bridges, Tunnels, and Elevated Highways - Includes tunnels, elevated highways, viaducts, and bridges.

Dam and Reservoir Construction - Includes all dams and reservoirs.

Marine Construction - Includes dredging, underwater rock removal, breakwaters, navigational channels, dikes, jetties, locks, etc.

Harbor and Port Facility Construction - Includes the construction of docks, piers, wharves, etc.

Conservation and Development Construction - Includes land reclamation, irrigation projects, drainage canals, levees, flood control projects, etc.

Power and Communication Transmission Lines, Towers, and Related Facilities - Includes telephone and telegraph lines, television and radio towers, electric light and power facilities, etc.

Sewers, Water Mains, and Related Facilities - Includes sanitary and storm sewers, water supply systems, and related facilities.

Pipeline Construction - Includes pipeline construction for the transmission of gas and petroleum products, liquid oxygen, etc.

Mass Transit Construction - Includes railroads, subways, elevated railways, etc.

Heavy Industrial Facilities - Includes blast furnaces, petroleum refineries, chemical complexes, mining appurtenances (such as tipples and washeries), etc.

Other Types of Construction Work - Includes any types of construction not covered by the above categories.

Appendix B

Survey Data Describing the Role of the Project Manager

APPENDIX B

Organization Type OWNER	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	5	2	
Prepare project definition	2	4	4
Perform market/demand analysis		1	2
Prepare preliminary budget estimates	2	3	6
Evaluate project return on investment	3	1	
Determine project staging/timing	2	8	6
Determine financing requirements (cash flow)	2	2	2
Determine technical feasibility	2	6	2
Determine socio-political constraints	1	2	1
Determine environmental constraints	2	3	5
Plan, seek and obtain equity participation		1	
Plan, seek and obtain mortgage financing		1	
Plan, seek and obtain construction financing		1	1
Obtain legislative funding		1	
Authorize project	3	3	
Site Acquisition			
Perform location analysis	1	3	3
Select site(s)	2	6	2
Negotiate control of site(s)	1	3	
Obtain necessary public agency approval of desired site(s)	2	1	4
Obtain local zoning waivers or modifications	1	1	4
Provide relocation assistance		1	
Planning and Design			
Assemble design team	1	5	1
Assemble design/construct team	2	3	1
Define design program requirements		7	2
Establish design schedule		7	4
Develop conceptual design		5	3
Develop detailed design		3	5
Prepare design documents		5	2
Review and/or approve design documents		6	5
Prepare project cost estimates	1	5	7

Organization Type OWNER

Coordinate design activities within organization		4	6
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)		6	7
Prepare environmental impact statement		4	2
Conduct public hearings	1	1	
Obtain regulatory approvals (building permits, etc.)		4	3

Contract Award

Type of Contract:

4 Design
11 Construction
6 Design/Construction
1 Other

Prepare request for bid/proposal	2	7	6
Prepare bid/proposal	2	2	7
Evaluate bid/proposal	3	6	6
Negotiate contract	5	5	3
Award contract	3	8	

Construction

Assemble construction team	3	5	4
Schedule construction	2	4	5
Determine construction methods and procedures	2	4	5
Monitor construction costs		8	8
Establish inspection/quality control system	2	6	6
Inspect construction			
Daily	1	6	
Periodic		9	5
Establish billable quantities (for cost-plus, unit cost contracts)	1	4	7
Estimate percent completion		6	9
Prepare application for progress payment	2	2	6
Approve application for progress payment	1	6	8
Accept completed work		6	7
Prepare shop drawings	1		4
Approve shop drawings	4	5	6
Purchase construction materials	2	3	8
Hire subcontractors, labor force, equipment		2	4
Negotiate change orders		6	8
Supervise field construction personnel		2	4

Organization Type OWNER

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)			5
Negotiate labor disputes and/or contracts	1	2	2
Marketing and Initial Operation			
Prepare operating (including maintenance) budget			1
Prepare operating and maintenance schedules		2	3
Conduct trial and debugging operations		2	5
Direct advertising/promotion campaign			1
Conduct lease/sale/rent negotiations		1	
Determine space allocation for tenant activities		1	
Purchase and/or install tenant equipment and furnishings		1	2

Organization Type DEVELOPER

Coordinate design activities within organization		7	1
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)		9	1
Prepare environmental impact statement	2	4	1
Conduct public hearings	1	2	3
Obtain regulatory approvals (building permits, etc.)		7	7

Contract Award

Type of Contract:

7 Design
9 Construction
1 Design/Construction
1 Other

Prepare request for bid/proposal	1	4	6
Prepare bid/proposal	1	5	4
Evaluate bid/proposal	1	8	4
Negotiate contract	3	9	6
Award contract	2	8	6

Construction

Assemble construction team	4	6	5
Schedule construction	2	5	6
Determine construction methods and procedures	2	4	8
Monitor construction costs	2	9	6
Establish inspection/quality control system	3	5	5
Inspect construction			
Daily	2	3	6
Periodic	1	7	4
Establish billable quantities (for cost-plus, unit cost contracts)	3	3	7
Estimate percent completion	2	6	7
Prepare application for progress payment	3	2	5
Approve application for progress payment	4	6	3
Accept completed work	4	6	4
Prepare shop drawings		1	8
Approve shop drawings	1	2	8
Purchase construction materials	2	2	9
Hire subcontractors, labor force, equipment	4	6	5
Negotiate change orders	4	7	5
Supervise field construction personnel	2	4	5

APPENDIX B

Organization Type DEVELOPER	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	3	5	4
Prepare project definition	3	5	3
Perform market/demand analysis	3	2	5
Prepare preliminary budget estimates	1	8	6
Evaluate project return on investment		7	4
Determine project staging/timing	3	7	4
Determine financing requirements (cash flow)	3	6	3
Determine technical feasibility	2	5	7
Determine socio-political constraints	4	1	3
Determine environmental constraints	1	3	5
Plan, seek and obtain equity participation	4		4
Plan, seek and obtain mortgage financing	3	1	4
Plan, seek and obtain construction financing	3	1	4
Obtain legislative funding	1		1
Authorize project	5		2
Site Acquisition			
Perform location analysis	1	2	6
Select site(s)	2	3	3
Negotiate control of site(s)		5	2
Obtain necessary public agency approval of desired site(s)	2	8	2
Obtain local zoning waivers or modifications	1	8	3
Provide relocation assistance		2	2
Planning and Design			
Assemble design team	2	8	2
Assemble design/construct team	1	8	1
Define design program requirements	2	7	3
Establish design schedule	1	7	5
Develop conceptual design		3	8
Develop detailed design		1	10
Prepare design documents			9
Review and/or approve design documents	1	9	4
Prepare project cost estimates	1	6	10

Organization Type DEVELOPER

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)	1	2	6
Negotiate labor disputes and/or contracts		5	4
Marketing and Initial Operation			
Prepare operating (including maintenance) budget	2	2	4
Prepare operating and maintenance schedules	1	2	5
Conduct trial and debugging operations		2	4
Direct advertising/promotion campaign		2	3
Conduct lease/sale/rent negotiations		3	3
Determine space allocation for tenant activities	2	2	2
Purchase and/or install tenant equipment and furnishings		1	5

APPENDIX B

Organization Type ARCHITECT	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	1	3	1
Prepare project definition		5	
Perform market/demand analysis	1		2
Prepare preliminary budget estimates		4	1
Evaluate project return on investment	1	1	1
Determine project staging/timing	1	4	1
Determine financing requirements (cash flow)		4	
Determine technical feasibility	1	1	2
Determine socio-political constraints		3	
Determine environmental constraints	1	3	
Plan, seek and obtain equity participation			
Plan, seek and obtain mortgage financing			
Plan, seek and obtain construction financing			
Obtain legislative funding			
Authorize project			
Site Acquisition			
Perform location analysis	1		2
Select site(s)	1	1	
Negotiate control of site(s)			
Obtain necessary public agency approval of desired site(s)	1	3	1
Obtain local zoning waivers or modifications		2	
Provide relocation assistance			
Planning and Design			
Assemble design team	3	3	
Assemble design/construct team	1	1	
Define design program requirements	2	3	1
Establish design schedule	2	4	
Develop conceptual design	1	2	3
Develop detailed design	1	1	3
Prepare design documents	1	1	3
Review and/or approve design documents	1	4	
Prepare project cost estimates	1	1	2

Organization Type ARCHITECT

Coordinate design activities within organization	1	4	1
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)	1	3	1
Prepare environmental impact statement	1	2	1
Conduct public hearings		2	
Obtain regulatory approvals (building permits, etc.)	1	1	1

Contract Award

Type of Contract:
- 2 Design
- 5 Construction
- Design/Construction
- 1 Other

Prepare request for bid/proposal		3	2
Prepare bid/proposal		2	1
Evaluate bid/proposal		2	2
Negotiate contract		2	2
Award contract		2	2

Construction

Assemble construction team			1
Schedule construction		2	1
Determine construction methods and procedures		2	
Monitor construction costs		3	
Establish inspection/quality control system		1	2
Inspect construction			
Daily			1
Periodic		2	2
Establish billable quantities (for cost-plus, unit cost contracts)			1
Estimate percent completion		2	1
Prepare application for progress payment		1	
Approve application for progress payment		2	1
Accept completed work		1	2
Prepare shop drawings		1	
Approve shop drawings		2	3
Purchase construction materials			
Hire subcontractors, labor force, equipment			
Negotiate change orders			3
Supervise field construction personnel		1	1

Organization Type ARCHITECT

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)			
Negotiate labor disputes and/or contracts			2
Marketing and Initial Operation			
Prepare operating (including maintenance) budget			1
Prepare operating and maintenance schedules			1
Conduct trial and debugging operations			1
Direct advertising/promotion campaign			
Conduct lease/sale/rent negotiations			
Determine space allocation for tenant activities			
Purchase and/or install tenant equipment and furnishings			

APPENDIX B

Organization Type ENGINEER	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	5	3	3
Prepare project definition	3	7	4
Perform market/demand analysis	1		1
Prepare preliminary budget estimates		2	10
Evaluate project return on investment		1	3
Determine project staging/timing	1	7	5
Determine financing requirements (cash flow)		1	3
Determine technical feasibility	2	5	8
Determine socio-political constraints		1	3
Determine environmental constraints		2	6
Plan, seek and obtain equity participation			1
Plan, seek and obtain mortgage financing			
Plan, seek and obtain construction financing			1
Obtain legislative funding			1
Authorize project			1
Site Acquisition			
Perform location analysis	1	1	5
Select site(s)	2	1	4
Negotiate control of site(s)			1
Obtain necessary public agency approval of desired site(s)	2	1	2
Obtain local zoning waivers or modifications	1		1
Provide relocation assistance			
Planning and Design			
Assemble design team	2	5	4
Assemble design/construct team			2
Define design program requirements		7	2
Establish design schedule	2	3	6
Develop conceptual design	1	4	6
Develop detailed design		2	9
Prepare design documents		1	10
Review and/or approve design documents		5	7
Prepare project cost estimates		1	11

Organization Type ENGINEER

Coordinate design activities within organization	1	3	6
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)		7	3
Prepare environmental impact statement	1	1	6
Conduct public hearings			2
Obtain regulatory approvals (building permits, etc.)		3	3

Contract Award

Type of Contract:

2 Design
6 Construction
____ Design/Construction
2 Other

Prepare request for bid/proposal	1	1	5
Prepare bid/proposal			6
Evaluate bid/proposal	1	3	4
Negotiate contract	1	1	2
Award contract	2		1

Construction

Assemble construction team			
Schedule construction			2
Determine construction methods and procedures			1
Monitor construction costs			4
Establish inspection/quality control system	1		2
Inspect construction			
Daily		1	1
Periodic		1	4
Establish billable quantities (for cost-plus, unit cost contracts)		1	2
Estimate percent completion		1	3
Prepare application for progress payment			2
Approve application for progress payment	1	1	3
Accept completed work		2	3
Prepare shop drawings			1
Approve shop drawings		1	7
Purchase construction materials			
Hire subcontractors, labor force, equipment			
Negotiate change orders		2	3
Supervise field construction personnel			1

Organization Type ENGINEER

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)			
Negotiate labor disputes and/or contracts			
Marketing and Initial Operation			
Prepare operating (including maintenance) budget			
Prepare operating and maintenance schedules			3
Conduct trial and debugging operations			3
Direct advertising/promotion campaign			
Conduct lease/sale/rent negotiations			
Determine space allocation for tenant activities			
Purchase and/or install tenant equipment and furnishings			

APPENDIX B

Organization Type CONTRACTOR	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	3	1	
Prepare project definition	2	1	1
Perform market/demand analysis		1	
Prepare preliminary budget estimates	3		3
Evaluate project return on investment		1	
Determine project staging/timing	1	2	
Determine financing requirements (cash flow)	1		
Determine technical feasibility	1	1	
Determine socio-political constraints	1		
Determine environmental constraints		1	
Plan, seek and obtain equity participation		1	
Plan, seek and obtain mortgage financing	1		
Plan, seek and obtain construction financing	1		
Obtain legislative funding	1		
Authorize project	1		
Site Acquisition			
Perform location analysis			
Select site(s)			
Negotiate control of site(s)			
Obtain necessary public agency approval of desired site(s)			
Obtain local zoning waivers or modifications			
Provide relocation assistance			
Planning and Design			
Assemble design team		1	
Assemble design/construct team			1
Define design program requirements		1	
Establish design schedule		1	
Develop conceptual design			
Develop detailed design			
Prepare design documents			
Review and/or approve design documents			1
Prepare project cost estimates	1	1	3

Organization Type CONTRACTOR

Coordinate design activities within organization		1	2
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)			2
Prepare environmental impact statement	1		
Conduct public hearings			
Obtain regulatory approvals (building permits, etc.)			

Contract Award

Type of Contract:
1 Design
8 Construction
2 Design/Construction
1 Other

Prepare request for bid/proposal			3
Prepare bid/proposal	1	2	3
Evaluate bid/proposal	1	1	3
Negotiate contract	1	2	4
Award contract	1	1	1

Construction

Assemble construction team	2	12	2
Schedule construction		10	7
Determine construction methods and procedures		7	10
Monitor construction costs		5	12
Establish inspection/quality control system		3	11
Inspect construction			
Daily		6	8
Periodic		9	6
Establish billable quantities (for cost-plus, unit cost contracts)		2	12
Estimate percent completion		5	11
Prepare application for progress payment		4	10
Approve application for progress payment	1	6	6
Accept completed work	2	2	6
Prepare shop drawings		2	9
Approve shop drawings		3	10
Purchase construction materials		2	15
Hire subcontractors, labor force, equipment	1	7	10
Negotiate change orders		11	7
Supervise field construction personnel		4	12

Organization Type CONTRACTOR

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)	1	1	14
Negotiate labor disputes and/or contracts	3	11	3
Marketing and Initial Operation			
Prepare operating (including maintenance) budget		1	
Prepare operating and maintenance schedules			
Conduct trial and debugging operations			1
Direct advertising/promotion campaign			
Conduct lease/sale/rent negotiations			
Determine space allocation for tenant activities			
Purchase and/or install tenant equipment and furnishings			2

APPENDIX B

Organization Type DESIGN/CONSTRUCT	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	9	3	6
Prepare project definition	5	11	5
Perform market/demand analysis	5	2	3
Prepare preliminary budget estimates	2	12	10
Evaluate project return on investment	2	7	5
Determine project staging/timing	4	11	11
Determine financing requirements (cash flow)	7	4	7
Determine technical feasibility	4	4	5
Determine socio-political constraints	3	2	7
Determine environmental constraints	3	3	9
Plan, seek and obtain equity participation	1	2	1
Plan, seek and obtain mortgage financing	3		2
Plan, seek and obtain construction financing	3		1
Obtain legislative funding	1	1	
Authorize project	4	1	
Site Acquisition			
Perform location analysis	3	5	5
Select site(s)	3	4	3
Negotiate control of site(s)	4		1
Obtain necessary public agency approval of desired site(s)	2	2	7
Obtain local zoning waivers or modifications	3	2	4
Provide relocation assistance	5		3
Planning and Design			
Assemble design team	3	8	9
Assemble design/construct team	3	11	7
Define design program requirements	2	10	11
Establish design schedule	1	11	12
Develop conceptual design	2	6	14
Develop detailed design	2	2	15
Prepare design documents	2	2	15
Review and/or approve design documents	2	6	12
Prepare project cost estimates	2	11	11

Organization Type DESIGN/CONSTRUCT

Coordinate design activities within organization	1	10	12
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)	1	8	12
Prepare environmental impact statement	2		12
Conduct public hearings	2		1
Obtain regulatory approvals (building permits, etc.)	3		11

Contract Award

Type of Contract:

6 Design
11 Construction
14 Design/Construction
3 Other

Prepare request for bid/proposal	1	4	15
Prepare bid/proposal	1	4	18
Evaluate bid/proposal	1	8	14
Negotiate contract	2	9	11
Award contract	2	5	12

Construction

Assemble construction team	4	6	12
Schedule construction	1	11	13
Determine construction methods and procedures	4	6	13
Monitor construction costs	2	8	15
Establish inspection/quality control system	1	8	12
Inspect construction			
Daily	1	1	10
Periodic	2	6	12
Establish billable quantities (for cost-plus, unit cost contracts)		4	15
Estimate percent completion	1	5	16
Prepare application for progress payment	1	1	17
Approve application for progress payment	1	5	11
Accept completed work	2	8	11
Prepare shop drawings	1	1	15
Approve shop drawings	2	1	18
Purchase construction materials	1	1	17
Hire subcontractors, labor force, equipment	3	6	15
Negotiate change orders	2	12	11
Supervise field construction personnel	2	4	15

Organization Type DESIGN/CONSTRUCT

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)		3	13
Negotiate labor disputes and/or contracts	2	4	13
Marketing and Initial Operation			
Prepare operating (including maintenance) budget	2	1	1
Prepare operating and maintenance schedules		3	6
Conduct trial and debugging operations			9
Direct advertising/promotion campaign	2		1
Conduct lease/sale/rent negotiations	2		1
Determine space allocation for tenant activities	2		1
Purchase and/or install tenant equipment and furnishings	2		2

APPENDIX B

Organization Type PUBLIC AGENCY-HIGHWAY	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	3	1	2
Prepare project definition	1	4	2
Perform market/demand analysis	1		1
Prepare preliminary budget estimates		4	3
Evaluate project return on investment	1	2	
Determine project staging/timing	3	7	2
Determine financing requirements (cash flow)	1	2	
Determine technical feasibility	1	2	7
Determine socio-political constraints	1	1	4
Determine environmental constraints	2	3	5
Plan, seek and obtain equity participation			1
Plan, seek and obtain mortgage financing			
Plan, seek and obtain construction financing		1	
Obtain legislative funding	1	1	
Authorize project	1		
Site Acquisition			
Perform location analysis		1	2
Select site(s)	1		1
Negotiate control of site(s)			
Obtain necessary public agency approval of desired site(s)			1
Obtain local zoning waivers or modifications			
Provide relocation assistance			
Planning and Design			
Assemble design team		3	6
Assemble design/construct team	1		5
Define design program requirements	1	3	5
Establish design schedule	1	4	5
Develop conceptual design	1	2	5
Develop detailed design	1	1	8
Prepare design documents	2	2	7
Review and/or approve design documents	1	5	6
Prepare project cost estimates	3	5	7

Organization Type PUBLIC AGENCY-HIGHWAY

Coordinate design activities within organization	1	3	7
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)	1	3	8
Prepare environmental impact statement	2		2
Conduct public hearings	1	1	3
Obtain regulatory approvals (building permits, etc.)			1

Contract Award

Type of Contract:
1 Design
8 Construction
Design/Construction
1 Other

Prepare request for bid/proposal		1	
Prepare bid/proposal		1	1
Evaluate bid/proposal	1	2	2
Negotiate contract		1	2
Award contract	1	1	2

Construction

Assemble construction team	3	4	9
Schedule construction	2	5	5
Determine construction methods and procedures	2	5	7
Monitor construction costs	2	5	10
Establish inspection/quality control system	3	5	12
Inspect construction			
Daily	1	4	9
Periodic	3	7	11
Establish billable quantities (for cost-plus, unit cost contracts)	2	3	13
Estimate percent completion	1	4	14
Prepare application for progress payment	1	1	14
Approve application for progress payment	1	8	10
Accept completed work	2	11	7
Prepare shop drawings		1	1
Approve shop drawings	2	2	6
Purchase construction materials		1	
Hire subcontractors, labor force, equipment		1	2
Negotiate change orders	3	8	8
Supervise field construction personnel	3	8	10

Organization Type PUBLIC AGENCY-HIGHWAY

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)	2	3	12
Negotiate labor disputes and/or contracts	1	3	5
Marketing and Initial Operation			
Prepare operating (including maintenance) budget			1
Prepare operating and maintenance schedules			1
Conduct trial and debugging operations			
Direct advertising/promotion campaign			
Conduct lease/sale/rent negotiations			
Determine space allocation for tenant activities			
Purchase and/or install tenant equipment and furnishings			

APPENDIX B

Organization Type PUBLIC AGENCY - BUILDING	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	4	1	1
Prepare project definition	2	2	2
Perform market/demand analysis		1	3
Prepare preliminary budget estimates	1	4	5
Evaluate project return on investment	1	1	1
Determine project staging/timing	3	6	3
Determine financing requirements (cash flow)	1	3	3
Determine technical feasibility	2	5	5
Determine socio-political constraints	2	1	3
Determine environmental constraints	4		6
Plan, seek and obtain equity participation			1
Plan, seek and obtain mortgage financing			
Plan, seek and obtain construction financing	2		2
Obtain legislative funding	2		2
Authorize project	4	1	2
Site Acquisition			
Perform location analysis	1		1
Select site(s)	1		3
Negotiate control of site(s)	2		2
Obtain necessary public agency approval of desired site(s)	1		1
Obtain local zoning waivers or modifications	1	2	
Provide relocation assistance	2	1	1
Planning and Design			
Assemble design team	2	1	6
Assemble design/construct team	2	2	4
Define design program requirements	1	4	4
Establish design schedule		5	5
Develop conceptual design	1	1	5
Develop detailed design	1		6
Prepare design documents	2	2	5
Review and/or approve design documents	2	4	7
Prepare project cost estimates	1	3	7

Organization Type PUBLIC AGENCY - BUILDING

Coordinate design activities within organization	1	3	4
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)	2	2	4
Prepare environmental impact statement		2	4
Conduct public hearings			1
Obtain regulatory approvals (building permits, etc.)		2	3

Contract Award

Type of Contract:

6 Design
13 Construction
4 Design/Construction
1 Other

Prepare request for bid/proposal		1	7
Prepare bid/proposal		1	6
Evaluate bid/proposal	4	1	4
Negotiate contract	4	1	3
Award contract	4		4

Construction

Assemble construction team		5	5
Schedule construction	2	6	5
Determine construction methods and procedures		6	6
Monitor construction costs	2	6	8
Establish inspection/quality control system	1	7	5
Inspect construction			
Daily			7
Periodic		8	4
Establish billable quantities (for cost-plus, unit cost contracts)		2	5
Estimate percent completion		4	6
Prepare application for progress payment		1	4
Approve application for progress payment	2	8	2
Accept completed work	2	7	3
Prepare shop drawings	1		2
Approve shop drawings		2	5
Purchase construction materials		1	2
Hire subcontractors, labor force, equipment		3	3
Negotiate change orders	2	3	7
Supervise field construction personnel	1	3	6

Organization Type PUBLIC AGENCY - BUILDING

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)		3	6
Negotiate labor disputes and/or contracts		4	2
Marketing and Initial Operation			
Prepare operating (including maintenance) budget		1	2
Prepare operating and maintenance schedules		1	3
Conduct trial and debugging operations			1
Direct advertising/promotion campaign			
Conduct lease/sale/rent negotiations			
Determine space allocation for tenant activities			
Purchase and/or install tenant equipment and furnishings		1	2

APPENDIX B

PUBLIC AGENCY -
Organization Type HEAVY CONSTRUCTION

	A	B	C
Project Conception & Preliminary Analysis			
Conceive project	1	1	2
Prepare project definition	1	1	2
Perform market/demand analysis		2	1
Prepare preliminary budget estimates		2	2
Evaluate project return on investment		2	2
Determine project staging/timing	1	3	1
Determine financing requirements (cash flow)	1	2	
Determine technical feasibility	1	2	2
Determine socio-political constraints	1	1	3
Determine environmental constraints		2	3
Plan, seek and obtain equity participation		1	1
Plan, seek and obtain mortgage financing			
Plan, seek and obtain construction financing			1
Obtain legislative funding	1	1	2
Authorize project	1		2
Site Acquisition			
Perform location analysis		1	2
Select site(s)		1	2
Negotiate control of site(s)			3
Obtain necessary public agency approval of desired site(s)			3
Obtain local zoning waivers or modifications			3
Provide relocation assistance			3
Planning and Design			
Assemble design team		2	1
Assemble design/construct team			2
Define design program requirements		2	1
Establish design schedule		2	1
Develop conceptual design		1	1
Develop detailed design			2
Prepare design documents		1	1
Review and/or approve design documents	1		3
Prepare project cost estimates			4

PUBLIC AGENCY -
Organization Type HEAVY CONSTRUCTION

Coordinate design activities within organization		2	2
Coordinate design with activities outside organization (other designers, public agencies, owner, contractor, construction manager, etc.)		1	3
Prepare environmental impact statement			4
Conduct public hearings	1	1	2
Obtain regulatory approvals (building permits, etc.)			1

Contract Award

Type of Contract:
1 Design
1 Construction
1 Design/Construction
_____ Other

Prepare request for bid/proposal		1	1
Prepare bid/proposal			2
Evaluate bid/proposal	1		2
Negotiate contract	1		1
Award contract	1		1

Construction

Assemble construction team	1	1	1
Schedule construction			2
Determine construction methods and procedures	1		
Monitor construction costs			2
Establish inspection/quality control system		2	
Inspect construction			
Daily		1	1
Periodic		2	1
Establish billable quantities (for cost-plus, unit cost contracts)		1	1
Estimate percent completion		1	
Prepare application for progress payment		1	
Approve application for progress payment		1	
Accept completed work	1	2	1
Prepare shop drawings			1
Approve shop drawings			1
Purchase construction materials			1
Hire subcontractors, labor force, equipment			
Negotiate change orders		2	1
Supervise field construction personnel		1	

PUBLIC AGENCY -
Organization Type HEAVY CONSTRUCTION

Provide construction and/or field staff personnel administration (timekeeping, payroll, etc.)			1
Negotiate labor disputes and/or contracts			1
Marketing and Initial Operation			
Prepare operating (including maintenance) budget			3
Prepare operating and maintenance schedules			2
Conduct trial and debugging operations			2
Direct advertising/promotion campaign			
Conduct lease/sale/rent negotiations			1
Determine space allocation for tenant activities			
Purchase and/or install tenant equipment and furnishings			