Managing AEC Projects to Success

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OVERVIEW: MANAGING AEC PROJECTS TO SUCCESS

Frequently in the AEC industry projects that are completed successfully with regard to time, cost and quality result in dissatisfaction, conflict, and even unwelcome litigation—an outcome that can be avoided by learning how to successfully manage a project from beginning to end. Successful project management requires looking at the economic, political, physical and social aspects of each project as well as perceiving each project as a linked chain of measured achievements. Essentially, project success in the AEC industry requires conceptual thinking.

This white paper will provide a solid foundation with regard to the procedures necessary for successful project management. It includes critical information for owners, owner representatives, architects, engineers, and contractors to help manage projects to success and will discuss the choices, limitations, and expectations from the viewpoint of the owner, the design professional, and the contractor. It will also provide recommendations for the increasingly important concerns of jobsite health and safety.

INTRODUCTION: DEFINING PROJECT MANAGEMENT

A well-defined and commonly accepted idea is that project management can be defined as the control of time, cost, and quality according to the requirements of the owner. However, the general business environment to which construction projects respond consists of economic, political, physical, and social aspects. Therefore, the previous definition of project management does not address all the grounds mentioned. Often, projects completed with apparent success still end in conflict and legal action. Good project management can improve these outcomes if project control systems are created that effectively address time, cost, quality, and conflict.

Consider this: in one particular region or country, construction projects at any given time all take place in similar economic, political, physical, and social environments. When working in a different region, these aspects become explicit and vital to the success of the project. A manager or consultant who has no understanding of these issues is leaving a lot to chance.

At the project level, the task environment also has four facets, each of which is a microcosm of its counterpart in the general environment. The economic environment infringes upon the project in terms of the financial plans and targets. Although economics is a much wider issue than finance, this is the dominant effect. Similarly, in terms of the way in which people and power groups interact, the political environment is evident in the policy of the owner and project team. The physical environment dictates what is technologically possible, and therefore the technological task is a consequence of the general physical environment. Finally, the social environment is manifested in the way society establishes legal institutions, the legal framework of common law, statutes, and contractual relations.

THE FUNCTIONS OF PROJECT MANAGEMENT

Construction project management requires knowledge of modern management as well as a good understanding of the design and construction process. Construction projects have a specific set of objectives and constraints, such as a required time frame for completion. Specifically, project management in construction encompasses a set of objectives that may be accomplished by implementing a series of operations subject to resource constraints.

There are potential conflicts between the stated objectives with regard to scope, cost, time and quality, and the constraints imposed on human and financial resources. These conflicts should be resolved at the

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onset of a project by making the necessary tradeoff or creating new alternatives. Subsequently, the functions of project management for construction generally include the following:

- **FOR THE OWNER AND THE DESIGN PROFESSIONAL** Plans and specification of project objectives including delineation of scope, budgeting, scheduling, setting performance requirements, and selecting project participants
- **FOR THE CONTRACTOR** Maximization of efficient resource utilization through procurement of labor, materials, and equipment according to the prescribed schedule and plans
- **FOR THE OWNER, THE DESIGN PROFESSIONAL, AND THE CONTRACTOR** Implementation of various operations through proper coordination and control of planning, design, estimating, contracting and construction process
- **FOR THE OWNER, THE DESIGN PROFESSIONAL, AND THE CONTRACTOR** Development of effective communications and mechanisms for resolving conflicts among the various participants

Plans and Specifications of Project Objectives

The programming of capital projects is shaped by the strategic plan of an organization, which is influenced by market demands and resource constraints. The programming process associated with planning and feasibility studies sets the priorities and timing for initiating various projects to meet the overall objectives of the organization. However, once this decision is made to initiate a project, market pressure may dictate timely completion of the facility.

Among the various types of construction, the influence of market pressure on the timing of initiating a facility is obvious in industrial construction. Demand for an industrial product may be short-lived, and if a company does not hit the market first, there may not be a demand for the product later. You may think these situations are unique only to businesses with intense competition for national and/or international markets, but that is not the case; this competition also happens in public and non-profit organizations. In the 1990s, for example, when the crime rate was high, state counties were competing for the location of detention facilities in order to obtain state and federal funds.

In order to gain time, some owners are willing to forego a thorough planning and feasibility study so as to proceed with a project with inadequate definition of the project scope. Invariably, subsequent changes in project scope will increase construction costs. However, if the owner can derive reasonable profits from the operation of a completed facility, the project is considered a success even if construction costs far exceed the estimate based on an inadequate scope definition. This attitude is wrong, but it is difficult to argue that profits might be higher if construction costs can be reduced without increasing the project duration.

However, some projects, notably some nuclear power plants, were clearly unsuccessful and abandoned before completion, and their failure must be attributed to inadequate planning and feasibility studies. The owner, organization, architect, or facility sponsor holds the key in influencing the construction costs of a project because any decision made at the start of a project life cycle has far greater influence than those made at later stages.

Project Budgeting

Facility investment decisions represent major commitments of the organization resources and have serious consequences on the profitability and financial stability of the organization. In the public sector, such decisions also affect the viability of facility programs and the credibility of the agency in charge of the programs. Therefore, it is important to evaluate facilities rationally with regard to the economic feasibility of individual projects. The cycle begins with the initial conception of the project and continues through planning, design, procurement, construction, start-up, operation, and maintenance. It ends with the disposal of a facility when it is no longer productive or useful.

Project Scheduling

For the owner, project scheduling is often dictated by financial or political reasons. For the design professional, after accepting a timeframe, project scheduling becomes a contractual obligation. For a contractor, project scheduling is the baseline for financial success or financial failure of a project. For the contractor, project scheduling is intended

to match the resources of equipment, materials, and labor with project work tasks over time.

Attitudes toward the formal scheduling of projects are often extreme. Many owners or design professionals require detailed construction schedules to be submitted by contractors as a means of monitoring the work progress. The actual work performed is commonly compared to the schedule to determine if construction is proceeding satisfactorily in time. After the completion of construction, similar comparisons between the planned schedule and the actual accomplishments are often considered to allocate liability for project delays due to changes requested by the owner, worker strikes, or other unforeseen circumstances.

Setting Performance Requirements

Functional compliance, quality control, and safety represent increasingly important concerns for project management. Defects or failures in constructed facilities can result in very large costs. Even with minor defects, reconstruction may be required and facility operations impaired. This can result in increased costs and delays as well as affect the professional standing of those involved with the project. In the worst case, failure may cause personal injury or fatalities. Good project management ensures the job is done right the first time and no major accidents occur on the project.

Selecting Project Participants

The executive management of the owner sets the overall policy and selects the appropriate individuals and/or divisions to take charge of a proposed project. Its policy will dictate how the project life cycle is divided between organizational divisions and which professionals should be engaged. Decisions by executive management will also influence the organization's possible adoption for project management. There are many ways to decompose a project into stages. The most common are:

Integration of Organizations A single or joint venture consisting of a number of organizations with a single objective. Two extremes may be cited as examples:

- Owner-builder operation in which all work will be handled in house by force account
- Turnkey operation in which all work is contracted to a vendor responsible for delivering the completed project

Separation of Organizations Numerous organizations serve as consultants or contractors to the owner, with different functions for design and construction. Typical examples are:

- Traditional sequence of design and construction
- Professional construction management

THE PROJECT MANAGER

Perhaps the most important decision made by the owner or organization is the selection of the project manager. The responsibility of the project manager is to ensure the design and construction of the project meets the cost, time, quality, and conflict control requirements established, and to accomplish this goal a project manager should perform the following functions:

- Establish Requirements
- Build Teamwork
- Provide Resources
- Evaluate Performance

Establish Requirements

Successful project management begins with formulating written requirements to specify the roles and responsibilities of each project participant. Established requirements should state basic organization requirements as well as particular requirements for the project. Total Project Management applies to the following sequential project phases:

- Planning (Conceptual design)
- Programming (Conceptual design)
- Budgeting (Conceptual design)
- Design (Schematic and Development)
- Documents (Construction documents)
- Bidding (Construction documents)
- Construction (Construction documents)
- Occupancy (Construction documents)

Build Teamwork

Project management functions should not only address technical issues, but also address people-related issues and encourage teamwork. Technical issues include checklists, inspections, interdisciplinary plan checks, and value engineering. People-related issues include building teamwork (partnership), defining expectations, and encouraging partnership as early as possible in the project process.

Provide Resources

Project management should provide the project budget, personnel, and time necessary to meet quality requirements for each project phase.

Evaluate Performance

During or upon completion of each project phase, and upon total project completion, the project manager should conduct Performance Evaluations to determine the following:

- Whether or not defined expectations have been met
- Whether or not defined problems have been resolved
- What is needed to rectify problems/issues
- What resources are needed

CONTROLS OF CONSTRUCTION PROJECTS

Project controls vary with the nature of the project at hand. In the traditional control model, project objectives were assumed to be fixed and means for achieving those objectives to be variable only as needed to recover from failure and conform to the original plan. Such a model is inadequate for controlling the larger, more complex projects we see today, which involve continuous negotiation between ends and means. Any control system needs an objective against which performance can be measured. If the control system is to have the beneficial effect of keeping the project oriented toward a meaningful result, the objective needs to be framed in terms that relate to the task. Project management will improve if control systems are created that effectively address **time**, **cost**, **quality**, and **conflict**.

TIME CONTROL

The most significant influence to the overall time of the construction project is the policy environment. Therefore, when considering time the policy of the owner needs to be precise. If all important parties are not involved, the end result may be an unrealistic timeframe and a failure to meet project expectations.

Both funding and functional activities greatly influence project timing. Governmental entities are subject to legislative approval and appropriation of funds, and a waiting period may be necessary for pending grants or fundraising efforts. With regard to functional activities, certain factors must be taken into account, such as planning construction on educational facilities during "school-out" days.

Conceptual Design Phase

At this phase Quality Control and Time Control are side by side. The owner must set a ***screening or magnitude estimate*** for the project by evaluating the functional requirements for the project and establishing a quality level. A facility constructed with custom-made or imported products will take considerably longer to complete than a facility designed with stock products available locally. Based on the established functional requirements and quality levels, a consultation with the design professional(s) must be arranged to establish a timeframe to have the drawings ready for bids.

At this point it is important to establish a schedule for the completion of design benchmarks, review and approvals, as well as for construction documents to be completed, approved, and ready for bids.

Schematic Design Phase

The Schematic Design Phase is the phase during which the users—unaware of the organization, political, or budget limitations—request their "wishful" list for the project. The Design Professional and the Project Manager should at this time instruct users about the project's possible limitations and design the project accordingly within the parameters of size, quality, and time. The plans should be reviewed with regard to functional requirements and established quality levels. If one or both exceeds the established limits, obtain approval for additional funding or timeframe changes, and keep a record of the approval. In the Schematic Design Phase the Project Manager should:

- ☑ Consult with the project architect/engineer to establish a realistic timeframe
- ☑ Develop a project schedule to indicate milestones to monitor progress or delays
- ☑ Summarize all changes and/or revisions to the project timeframe

Design Development Phase

Although the Design Development Phase may be the most important phase of managing a construction project, it is often the most neglected. During this phase the architects must define a project to be ready for construction documents. However, because the engineers are often unaware of the project's time, cost, and quality constraints, they design and specify systems and/or products that are inappropriate for the project limitations (e.g. planning high-end plumbing fixtures for a low-income housing project). ***It is imperative that the architect, design professionals, and project manager establish clear expectations before proceeding to the following phase***. These include:

- ☑ Verifying with vendors/suppliers that specified products will be available within the established times
- ☑ Minimize changes by thoroughly investigating the options for achieving a set objective.
- ☑ Analyze and obtain approval for justifiable changes to the timeframe.

Construction Phase Time Control

During the first two weeks of the construction phase, the contractor must submit the ***Schedule of Values*** and the ***Total Project Schedule***. After these documents have been reviewed and approved by the design professional and the project manager, they become the benchmarks for future project tracking.

A ***Monthly Construction Meeting*** should be scheduled during which the contractor must submit the ***Monthly Request for Payment*** and the ***Schedule of Project Progress***. The Monthly Construction Meeting shall be conducted with an established agenda and must be attended by the contractor's representatives and the project manager as well as the design professionals (including the architects, engineers, construction inspector, and testing laboratory representative). The Meeting Report, distributed to all interested parties, must indicate:

- ☑ Number of work days completed
- ☑ Actual percent completed
- ☑ Number of work days pending

The contractor must explain any delays as well as the projected method to recoup the time. All pending items must be numbered progressively. The time impact on the project must be evaluated carefully for any proposed change, and upper management must be informed of the project's progress.

PROJECT TRACKING

Tracking provides the avenues for monitoring and evaluating project progress. This is an area where many computerized tools are available, such as Microsoft Project® or Primavera Project Planner®. **Important project components to track include**:

- Planned work days for an activity or task
- Planned costs
- Number of work days completed
- Number of work days credited
- Percent completion expected

- Actual percent completed
- Actual costs
- Budget shortfalls/surplus

For a contractor, project or task schedules are intended to match the equipment, materials and labor with the project workforce over time. Successful scheduling can eliminate problems due to production bottlenecks; facilitate the timely procurement of necessary materials; and otherwise ensure the completion of a project by its projected completion date. Unfortunately, many project tracking schedules are incorrect from the start because of an owner's eagerness to complete a project or a design professional's willingness to accept an unrealistic project schedule. This can delay the overall project significantly. Poor selection of materials by the design professional, for example, may result in time wasted while waiting for the availability of specified materials. Such delays can also create havoc for owners who are eager to start using the constructed facilities.

DELAYS

Perhaps the most common complaint associated with construction claims is that of delays to contract performance; virtually all contractors acknowledge that delays are the most costly problem they may encounter on projects.

Delays seldom result from a single catastrophic event but instead develop slowly during the course of the work. Minor delays are generally overlooked until the cumulative effect becomes financially burdensome. Often by the time a contractor recognizes there is a problem, many different parties have contributed to the situation.

Owner-caused delays are those which do not arise from labor disputes, weather, and force majeure (acts of God). They include an owner's procrastination in processing construction documents; difficulty making a decision within a reasonable time period when design/construction questions arise; failure to provide an unencumbered worksite; difficulties with coordination/progress of the work of other contractors under the direction of the owner; errors in project design/specifications; and a large number of change orders or individual change orders of significant impact. Regardless of their cause, delays always impact two key components: **time** and **money**.

COST CONTROL

Cost control is the activity that compares cost performance against the cost plan, adjusting one or the other based on the changing circumstances in the project financial environment.

GENERAL CONTROLS

The project manager must work closely with the design professional and all project consultants during all phases of design, documentation, and construction to undertake all appropriated detail cost studies of the project. Project Control Group Meetings may be required to ensure compliance.

Conceptual Phase Cost Planning

Using historical cost data when available, the owner must set a screening or magnitude estimate for the project by evaluating its functional and quality requirements. Cost planning ensures the emerging design needs and/or contingencies can be achieved within the budget and takes into account the form and shape of the building(s) to determine the most economic design solution. During the cost planning phase, owners will:

- Set target costs for each component or system of the building, infrastructure, and site facilities to provide a measurement for cost control;

- Prepare the ***Project Budget Estimate***, including forecast of future escalation costs
- Provide a ***Cashflow Forecast*** for project expenditures

COST CHECKING: A CRITICAL COMPONENT

Schematic Design Cost Planning

During the schematic design phase, cost checks must be prepared to identify all amendments and design changes. This phase includes:

- Preparing outline specifications
- Revising the cash flow forecast
- Summarizing (by the architect) all cost changes and providing the owner with a preliminary estimate of construction costs

Design Development Cost Checking

During the design development phase, cost checks must be prepared to identify all amendments and design changes. Costs for project systems—plumbing, mechanical, electrical, security, communications, telephone, etc.—must be detailed. At this time, the options for achieving a set objective should be thoroughly investigated to eliminate the need for changes later on. At this time, the cash flow forecast may need to be revised and a ***Detailed Cost Estimate*** should be prepared based on completed design development documents.

COST ESTIMATION

Cost control is essential to the success of any construction project, and cost estimating is one of the most important steps in project management. A cost estimate establishes the baseline of a project's cost at different stages of development. According to the American Association of Cost Engineers, cost engineering is defined as "that area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to the problem of cost estimation, cost control and profitability." Virtually all cost estimation is performed according to one or some combination of the following basic approaches:

- **PRODUCTION FUNCTION**
  In microeconomics, the relationship between the output of a process and the necessary resources is referred to as production function. In construction, production function may be expressed by the relationship between the volume of construction and a factor of production such as labor or capital. A production function relates the amount or volume of output to the various inputs of labor, material, and equipment.
- **EMPIRICAL COST INFERENCE**
  Empirical estimation of cost functions requires statistical techniques that relate the cost of constructing or operating a facility to a few important characteristics or attributes of the system. The role of statistical inference is to estimate the best parameter values or constants in an assumed cost function. Usually, this is accomplished by means of regression analysis techniques.
- **UNIT COSTS FOR BILL OF QUANTITIES**
  A unit cost is assigned to each of the facility components or tasks as represented by the bill of quantities. The total cost is the summation of the products of the quantities multiplied by the corresponding unit costs. The unit cost method is straightforward in principle but quite laborious in application.
- **ALLOCATION OF JOINT COSTS**
  Allocation of joint costs from existing accounts may be used to develop a cost function of an operation. The basic idea is that each expenditure item can be assigned to particular characteristics of the operation. Ideally, the allocation of joint costs should be causally related to the category of basic costs in an allocation process. However, a causal relationship between the allocation factor and the cost item cannot be identified or may not exist. For example, in construction projects, the accounts for basic costs may be classified according to (1) labor, (2) material, (3) construction equipment, (4) construction supervision, and (5) general office overhead. These basic costs may then be allocated proportionally to various tasks which are subdivisions of a project.

Construction Cost Estimates

Construction cost constitutes only a fraction (though a substantial fraction) of the total project cost. ***However, it is the part of the cost under the control of the project manager.*** The required levels of accuracy of construction cost estimates vary at different stages of project development, ranging from ballpark figures in the early stage to fairly reliable figures for budget control prior to construction. Since design decisions made at the beginning stage of a project life cycle are more tentative than those made at a later stage, the cost estimates made at the early stages are expected to be less accurate. Cost estimates can be classified into one of the three major categories:

- **DESIGN ESTIMATES**
  For the owner or the design professional, the types of cost estimates encountered run parallel with the planning and design of a project as follows:
  - Screening estimates (or magnitude estimates)
  - Preliminary estimates (or conceptual estimates)
  - Detailed estimates (or definitive estimates)
  - Professional estimates based on plans and specifications
- **BID ESTIMATES**
  For the contractor, a bid estimate submitted to the owner either for competitive bidding or negotiation consists of direct construction costs including field supervision, plus a markup to cover general overhead and profits. The cost of construction for bid proposals is usually derived from a combination of the following approaches:
  - Subcontractors' quotations
  - Quantity takeoffs
  - Construction procedures
- **CONTROL ESTIMATES**
  For monitoring the project during construction, a control estimate is derived from available information to establish:
  - Budget estimate for financing
  - Budget cost after construction contract
  - Estimated cost to completion during the construction progress

Unit Cost Method

If the design technology for a facility has been specified, the project can be decomposed into elements at various levels of detail for the purpose of cost estimation. The unit cost for each element in the bill of quantities must be assessed in order to compute the total construction cost. This method is applicable to both design estimates and bid estimates.

Allocation of Construction Cost Over Time

Since construction costs are incurred over the entire construction phase of the project, it is important to determine the amounts to be spent in various periods to obtain the cash flow profile, especially for large projects with a long duration. Also imperative is an examination of the percentage of work expected to be completed at various time periods to which the costs would be charged.

Considering the basic problem of determining the percentage of work completed during construction, one reliable method is based on the concept of value of work completed which is defined as the product of the budgeted labor hours per unit of production and the actual number of production units completed. It is expressed in budgeted hours for the work completed. Then, the percentage of completion at any stage is the ratio of the value of work completed to date and the value of work to be completed for the entire project. ***It is important to understand the trend of work progress during construction for evaluation and control***.

In general, the work on a construction project progresses gradually from the time of mobilization until it reaches a plateau; then the work slows gradually and finally stops at the time of completion.

QUALITY CONTROL

As with cost control, the most important decisions regarding the quality of a projected facility are made during the design and planning stages rather than during construction. It is during these preliminary stages that component configuration, material selection, and functional performance are decided. Quality control during construction consists largely of ensuring performance to the original design and planning decisions.

While conformance to design decisions is the primary focus of quality control, unforeseen circumstances may arise during the course of construction (such as incorrect design decisions or changes desired by an owner) which may require reevaluation of previous design decisions. Since later decisions are often based on better information regarding actual site conditions, the design decision at this stage may be more cost effective as a result. Now, the specification of quality requirements in the contract

documentation becomes extremely important. Quality requirements shall be clear and verifiable, so that all parties in the project can understand the requirements for conformance.

GENERAL CONTROLS

With regard to the construction project, quality refers to conformance to requirements. The quality of a facility is commonly established in the very early phase of the project, and the quality level is established when the project is funded. However, after a budget has been set for the project—commonly based on a magnitude estimate of the facility and historical cost data—the design professionals and the project manager may be confronted with the challenge of designing a larger facility within the limitations of the previously established project fund.

- **Conceptual Phase Quality Controls**
  During this phase a "screening or magnitude estimate" must be established by the owner by evaluating the functional and quality requirements for the project. Escalation costs and project contingencies should be included in the preliminary budget.
- **Schematics Quality Controls**
  At this point the owner must discuss with the users the program needs and the space requirements. Project constraints and limitations must be explained to ensure satisfaction and understanding on the part of the users, and project size and quality must be defined.
- **Design Development Quality Controls**
  During this important design phase the architects determine a project to be ready for construction documents. Engineers should be well informed of project constraints to avoid specifying systems/ products that may be inappropriate within the scope of the project limitations.
- **Construction Documents Quality Controls**
  Check and coordinate with other divisions—maintenance, communications, etc.—to prevent any potential interference with regard to the project's site. Incomplete or ambiguous plans or specifications mean additional risks for the contractor and consequently higher bids.

Quality must be in compliance with functional requirements as well. Carefully analyze risks that may be absorbed by the owner, design professionals or construction manager consultants in order to reduce the risks for the contractor. Conduct a review of the American with Disabilities Act and state requirement plans no later than at the 75% completion mark.

SAFETY IN CONSTRUCTION

Safety represents an increasingly important concern for project managers, architects, engineers, contractors and owners. Even minor failures in procedure may cause personal injuries or fatalities. Accidents during the construction process can result in personal injuries and significant costs. Indirect costs of insurance, inspection and regulation are increasing rapidly due to these increased indirect costs. Project managers must work to ensure the job is done correctly the first time and no major accidents occur on the project.

Safety during the construction project is influenced in large part by decisions made during the planning and design process. Some designs and resulting construction plans are difficult and dangerous to implement, whereas other comparable plans may considerably reduce the risk of accidents. For example, clear separation of traffic from construction zones during roadway rehabilitation can greatly reduce the possibility of accidental collisions. Beyond the design decisions, safety largely depends upon education, vigilance, cooperation, and common sense during the construction process. Workers should be constantly alert to the possibilities of accidents and avoid taking unnecessary risks.

In addition to routine OSHA worksite inspections, insurance companies often perform safety inspections during which safety inspectors will issue citations for all standard violations observed. Most construction accidents are caused by lack of common sense on the part of the worker and poor supervision from the managers. As a result, safety is largely the responsibility of the managers on site rather than that of public safety inspectors.

Safety and Project Management

Safety is a significant factor with regard to Cost, Time, and Quality controls. While contractors may pay insurance premiums directly, these costs are reflected in bid prices and contract amounts. Delays caused by injuries and illness can create unexpected costs to the owners; owners must ultimately pay all the costs of construction, including a significant proportion for worker injury and/or illness. Other significant portions of injury/illness costs are borne by workers themselves or society at large.

Various measures are available to improve jobsite safety in construction, several of which must occur before construction begins. These include design, choice of technology and education. Machinery safeguards should be established to notify operators of malfunctions and prevent injuries. Materials and work process choices may also influence safety in construction. The substitution of alternate materials in place of asbestos, for example, may reduce or eliminate the prospect of illnesses such as asbestosis.

Educating workers and managers in proper procedures and hazards can have a direct impact on jobsite safety. The realization of the large costs involved in construction injuries and illnesses provides a considerable motivation factor for safety education. Regular safety inspections and safety meetings have become standard practices in most jobsites, and also practiced and required by insurance companies.

WORK QUALITY SPECIFICATIONS

Work quality specifications are an important feature of design documents. Specifications of required quality and components represent part of the necessary documentation to describe a facility. Typically, this documentation includes any special provisions of the facility design as well as references to generally accepted specifications to be used during construction. Work quality specifications are widely available and issued in publications from organizations such as:

- **The American Society for Testing and Materials (ASTM)**
- **The American National Standard Institute (ANSI)**
- **The Construction Specifications Institute (CSI)**

While distinct specifications exist for particular activities (such as welding standards issued by the American Welding Society), general specifications must be modified to reflect local conditions, policies, available materials, local regulation, and other special circumstances. Because many institutions and testing companies issue certifications and specifications, a designer shall carefully select specifications of products and/or materials that can be tested for meeting or not meeting the requested performance.

Construction specifications normally consist of a series of instructions or prohibitions for specific operations. For example, the following specification illustrates a typical case for excavation for structures:

"Conform to elevations and dimensions shown on plan within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other constructions, and for inspection. In excavation for footing and foundations, take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive concrete."

This example specification requires judgment in application since some items are not precisely specified. For example, excavation must extend a "sufficient distance from footings". Obviously, the term "sufficient" in this case may be subject to varying interpretations. In contrast, a specification that "tolerances are within plus or minus a tenth of a foot" is subject to direct measurement.

Performance specifications have been developed for many construction operations. Rather than specifying the required construction process, these specifications refer to the required performance or quality of the finished facility. The exact method by which this performance is obtained is left to the construction contractor.

Total Quality Control

Quality control in construction typically involves ensuring compliance with minimum standards of material and workmanship in order to comply with the performance required for the facility.

Implied with regard to traditional quality control practices is the notion of an ***acceptable quality level***, which is an allowable fraction of defective items. Materials obtained from suppliers or work performed by a subcontractor is inspected and approved as acceptable if the estimated defective percentage is within the acceptable quality level.

In the ***total quality control system*** no defective items are allowed anywhere in the construction process. However, the zero-defect goal is nearly impossible; it makes it so that an organization is never satisfied with its quality control program even if defects are reduced substantially year after year. This concept and approach to quality control was first developed in manufacturing firms in Japan and Europe.

Total quality control is a commitment to quality expressed in all parts of an organization and typically involves many elements. Design reviews to ensure safe and effective construction procedures are a major element. Other elements include extensive training for personnel; shifting the responsibility for detecting defects from quality control inspectors to workers; and continually maintaining equipment. Workers' involvement with improved quality control measures is often formalized in quality circles, in which groups of workers meet regularly to make suggestions for quality improvement. Materials suppliers are also required to ensure zero defects in delivered goods.

The traditional microeconomic view of quality control includes an "**optimum**" proportion of defective items. Total quality control is difficult to apply, particularly in construction; the unique nature of each project, the variability of the workforce, the multitude of subcontractors, and the cost of necessary investments in education and procedures makes programs of total quality control in construction very difficult.

CONFLICT CONTROL

Organizations select people to manage a project based on their high level of personal productivity and their ability to get things done. As such, Project Managers are typically task-oriented people with a strong sense of urgency and a keen focus on getting started and finishing. However, that strong focus on completion can hinder the strategic thinking necessary to define the measurable results the project should achieve (and thus ensure success).

After the project starts, tasks can change at the drop of a hat because there is no clear vision of the end result; everyone has his or her own ideas and expectations. The thousands of decisions made during a project's life cycle must be channeled toward a clear, measured result, but too often the Project Manager does not find out about them until the project is nearly finished and the clients are unhappy.

It is no surprise that most unsuccessful projects are flawed simply because the front-end planning is weak or perhaps was never attempted. It is up to the Project Manager to clearly define success before the project starts. He or she must ask tough questions to the project owners and clients such as: How you will measure success at the end of the project? What do you really want to buy for all the money we are going to spend?

Getting answers to these questions forces the kind of conceptual thinking required at the front end of a project. Without an understanding of the desired results, the Project Manager cannot define success. However, by obtaining clear, concise answers, the Project Manager can drive progress toward the agreed-upon measures of success.

In answering these questions, we find that it is not only time, cost and quality controls which influence the success or failure of a project, but also the conflict controls involved. Defining success before you begin a project requires conceptual thinking, and again it helps to think of a project as a linked chain of measured achievements. The chain is created by starting at the end of the project; the last achievement is the stated definition of success by the owner. This success definition must be measurable and preferably quantifiable.

Completing the front end of a project is no easy task, often involving pressing people in higher positions to make difficult conceptual decisions. However, by doing so the Project Manager can obtain a clear definition of success from upper management, and the answers he or she is able to give the project team are crystal clear expectations of what they need to achieve.

Often, the ***political environment*** of the project is the major influence with regard to the timing of a project. Timing is influenced by many environmental factors, but the owner's attitude toward timing is an issue of policy. Therefore, when considering the time necessary to complete a project, the owner's policy needs to be absolutely clear. The ***legal environment*** also influences conflict control. Essentially, the purpose of contracts and conditions of engagement is to clarify enforceable promises and eliminate confusion and misperception.

Finally, while a certain amount of conflict between team members can be a healthy source of new ideas, just like

cost it needs to be controlled and addressed properly from the beginning. This requires changes in attitudes as well as the method of project management, and research shows that a technique called "**partnering**" excels over other management alternatives with regard to successful project management—particularly meeting the schedule, controlling costs, and owner satisfaction.

Partnering vs. Other Management Alternatives

Project management functions should address not only technical issues, but also people-related issues. These include fostering teamwork, defining expectations, and encouraging participation throughout the project process.

The primary purpose of ***partnering*** is to encourage teamwork by changing from traditional adversarial relationships to a cooperative team approach in order to avoid conflict, especially since the expectations of owners, contractors and design professionals are typically in line with one another. The partnering concept nurtures trust, collaborative problem-solving in obtaining common goals and objectives, open communication, and ultimately helps resolve and eliminate conflict.

GENERAL CONFLICT CONTROLS

Evaluate Performance

During or upon completion of each project phase, the Project Manager should conduct performance evaluations to:

- Define expectations
- Define problems
- Determine what is needed to rectify problems
- Estimate needed resources

Teamwork Performance

The Project Manager should assess team performance by conducting periodic evaluations for:

- Timeliness (remaining on schedule)
- Efficiency (staying within budget)
- Effectiveness to established quality requirements
- Compliance with project constraints

Encourage Dialogue with the Receiver

Telling is not the same thing as communicating. Clearly communicate your expectations (i.e. what you want, how you want it, and when you want it).

Provide Instructive Criticism, Avoid Destructive Criticism

Remember there is only one reason to criticize: to motivate someone to change behavior. When conflict arises, avoid destructive criticism and immediately provide positive, instructive criticism. (Note: In major projects the Project Manager is often outranked by many committee members, however he or she should be able to demand from them prompt and precise instructions or decisions in the best interest of the project.)

Record in Writing at all Meetings

Keep a record of everything discussed in meetings to avoid confusion and resulting conflict.

CONCEPTUAL PHASE CONFLICT CONTROLS

- Define the expectations of the users
- Communicate project constraints
- Verify magnitude estimate (Net vs. Gross)

Review Design Professional Services Contract

Do not use dates, use time. For example, "Design Development documents must be completed six weeks after approval of Schematic Phase Documents." If you use specific dates and the project is delayed for any reason (e.g. funding or environmental investigation), A/Es may claim additional compensation. Other items to be considered should be:

- Does the agreement clearly define the project scope?
- Does the agreement distinguish between basic and additional services?
- Does the agreement call for a fixed limit of construction costs?
- Does the agreement request the preparation of record drawings?

- Does the agreement provide for an equitable assignment of risk?

SCHEMATIC DESIGN CONFLICT CONTROLS

- Control users during the schematic phase
- Consolidate cost with quality as appropriate for the available funds

DESIGN DEVELOPMENT CONFLICT CONTROLS

At this stage, all environmental investigations must be completed satisfactorily:

- Secure ownership of the site
- Conduct a topographical survey and soil investigation
- Request a written report from the architect, engineers, and other consultants about project analysis, criteria, and recommendations
- Conduct a Review Meeting with organization users and maintenance representatives

CONSTRUCTION DOCUMENTS CONFLICT CONTROLS

Changes to the plans at this stage may create errors and omissions and thus should be documented accurately.

BIDDING PHASE CONFLICT CONTROLS

A pre-bid conference should not be a substitute for a poor set of plans and specifications. Mandatory attendance to a pre-bid conference should only be reserved for projects with special conditions. A Bid Form should clearly establish the criteria to be used for the award of "alternate bids" in order to eliminate any suspicion of bid manipulation.

Contractors should read, analyze, and understand the contract and evaluate the risks before bidding. If a contract has imposing language that is not negotiable and an appropriate cost cannot be included in the bid proposal to cover for the additional exposure, the contractor should seriously consider not bidding on the project.

In order to avoid conflict with the setting of the clock, place an "official clock" in a place visible to all the bidders approximately 30 minutes before the bidding deadline. Never accept a bid after the deadline. After the bids have been submitted, check the proposal for completeness. If one of the mandatory requirements is missing, do not read the bid.

CONTRACTING PHASE CONFLICT CONTROLS

When the Construction Contract is ambiguous, inherently unfair, or provides no remedies, changes often escalate into disputes.

CONSTRUCTION PHASE CONFLICT CONTROLS

Recognize and avoid potential claim situations. The Project Manager should be prompt in reviews and recommendations in order to prevent any delays on the part of the organization.

WARRANTIES CONFLICT CONTROLS

Many contractors and owners are under the impression that there is one-year warranty for defects implied in every construction contract. Unfortunately for contractors, the potential for extensive liability exists well beyond one year. In fact, even when a contractor has an express one-year warranty, he/she may be subject to long-term liability for defects and non-conformities.

Each state has its own Statute of Limitations. For example, Florida Statutes that deal with patent defects provide that actions must commence within four (4) years that are "founded in the design, planning, or construction of an improvement for real property…"

Many contracts contain an **express warranties provision** that materials and workmanship will be free from defects for a period of one year. Even this express language will not likely limit the contractor's responsibility for defects with other causes of action. It should be noted that express warranties can arise from oral transactions as well.

Therefore, it is important for a contractor to establish a policy for employees regarding oral representations and also to have a provision on the written contract that no oral representation will be construed to create additional liability.

Implied warranties are those warranties which exist outside of the specific language of the contract. The following are some implied warranties that are potential claims against a contractor:

- Warranty of Workmanship
- Warranty of Habitability
- Warranty of Fitness for a Particular Purpose

In addition to implied warranties and express warranties, in most states an owner can bring a claim against a contractor for violation of building codes.

Change Orders Consequences

Change Orders on a Construction Contract can have significant economic consequences for the contractor involved, and there is often disagreement between owners, architects, engineers, and contractors regarding exactly what constitutes a fair approach to estimating the price adjustment when changes are required.

In the absence of special conditions or provisions, contractors are entitled to base their original estimates on optimum crew sizing and the most economical pacing. When changes require the work scope to be completed in anything other than the most economical time period, costs are likely to increase.

The adjustment in Contract Sum and/or Contract Time is typically negotiated between the parties to the Contract by (a) acceptance of an agreed upon sum price by the contractor; or (b) by the contractor's cost and a mutually acceptable fixed or percentage fee.

Factors Affecting Productivity

There is not a set criterion for estimating Change Orders. In 1987, the Mechanical Contractors Association of America, Inc. conducted a study about factors affecting productivity which may be helpful in preparing original estimates and Change Orders. In fact, introduction of a given factor or job condition producing a degree of effect on productivity is already a Change Order.

CONSTRUCTION CLAIMS

Knowledge of the different types of construction claims may allow owners, design professionals, and contractors to recognize potential claim situations. Many of the claims types are interrelated, and frequently more than one may pertain to a particular situation.

Acceleration

Acceleration normally occurs when the scope of work is increased but the project schedule is not modified to compensate for the increased work. Acceleration also applies to situations in which the contractor is required to complete work in advance of the agreed upon construction schedule.

Constructive Change

A claim for constructive change applies to contract modifications that develop gradually and often are created without notice of the contractor. The nature or extent of construction work is often changed without the initiation of a change order. The question of compensation or time extension for the time of change is not clearly addressed by the contract; the same applies to the directed changes. A constructive change may be difficult to identify and document by the contractor because the effects of such change do not manifest themselves until near completion or after the project is completed. In fact, ***constructive change is often the indirect result of the conduct or actions of the owner's representatives,*** such as a

misinterpretation of the drawings/specifications that results in an increase in the contractor's cost.

Defective or Deficient Contract Documents (Errors and Omissions)

If the contractor is directed to proceed according with the defective or deficient contract documents, the contractor is not responsible for the consequences of the defects or deficiencies.

Delay

A delay is a situation in which the activity of one party is impeded by the inactivity, inability, or constraint of another party. When a delay occurs, the impacted party should document any resulting effects related to the delay.

Differing Site Conditions

This claim type is also known as "changed conditions" and involves different subsurface or foundation conditions stated in the contract. Differing site conditions may include any detrimental condition that affects work performance and that could not have been known or reasonably anticipated at the time the parties entered into the contract.

Directed Changes

This type of claim involves a situation in which a contractor is required to perform work that is considered a change in the contractor's scope of work. This change may be an addition or deletion of work, or the use of different methods, materials, or design. By definition, the owner recognizes the directed change, but there may be disagreement regarding the amount of compensation in time or money due to the contractor.

Interference

This claim situation frequently involves third-party constraints or disruptive influences imposed by the owner's contract administration. Contractors shall be able to provide efficient and productive performance without interference from the owner.

Knowledge Withheld

This type of claim supports allegations that the owner knowingly withheld facts that had a significant impact on the contractor's performance.

CONCLUSION

Successful project management begins with an understanding of the entire scope of a construction project from beginning to end. By effectively implementing control systems to address the key elements of time, cost, quality and conflict, project managers can ensure the timely success of a project and adherence to the defined expectation of all parties involved. By applying proven techniques to ensure effective planning, budgeting, cost estimation, quality control, conflict resolution, safety and other aspects of a project's life cycle, the Project Manager is able to complete satisfactory and successful projects.

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