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"THE APPLICATION OF TOTAL QUALITY MANAGEMENT TECHNIQUES IN DESIGN-BUILD
PROJECTS"

FOR:

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Abstract:

The application of total quality management principles in the construction industry, especially the ones that adopt design-build method of construction, is proven to have many benefits. These benefits manifest itself in more customer satisfaction, less work recycle, less cost of poor quality, less schedule delays, and future project prospects with the client. This paper talks about the journey of applying total quality management in these design-build projects and the learning and saving realized as result of doing that both for constructor and customer.

Introduction:

One of the most difficult yet thrilling aspects of project management in a design-build construction environment is trying to consistently and successfully balance project constraints to produce project success. This seemingly simple concept of balancing time, cost, quality, and scope has been either the savior or downfall for many design-build project managers. In fact, this delicate balance affects project managers of all types, including a special breed called owner representatives. While some may believe that owner representatives have a minimal impact on project performance and balancing project constraints, the authors believe the influence of owner representatives on the success or failure of a design-build project is significant. They also believe owner representatives must excel in a specific type of integration and management skills-soft or people skills-to positively contribute to the production of success on design-build projects.

Project Management - A Historical Basis:

Modern project management is a relatively young profession with a bright future. It has experienced rapid evolution from its conceptual roots as a set of skills to its emergence as a legitimate profession (Coates and Jarrett, Inc., 1999, p. 8). This evolution is expected to continue as change becomes the norm in our society, and as the need for "a profession that essentially manages change" (PMI, 1999, p. xi) becomes even more crucial.

The roots of project management are found in the works of visionaries such as Frederick Taylor and Henry Gantt. These pioneers are responsible for the development of skills that later became the foundation of a profession. Taylor was generally acknowledged as the "Father of Scientific Management." His theory of scientific management and his studies of work showed that the productivity of labor can be measured, analyzed, and improved by focusing on its elementary parts (Drucker, 2001, pp. 6-7). Gantt, a contemporary of Taylor, studied the sequence and duration of tasks in work processes. He is the creator of the Gantt chart, which uses task bars and milestones to synthesize project activities, sequences, durations, and resources into a coherent project schedule (Kerzner, 2001).

The skills and processes developed by Taylor, Gantt, and many others, are believed to be the impetus behind the development of modern processes for managing projects. Many believe that modern project management was born between the 1940s and 1960s, when massively engineered, complex military and government projects prompted managers to develop management techniques such as the Program Evaluation and Review Technique (PERT) and the Critical Path Method (CPM). These techniques and others assisted project managers with planning and control aspects of complex projects. (Van der Merwe, 1998).

The evolution of project management continues today. Wideman (1996, p. 1) states, "In the last couple of decades, project management has emerged as a business process tool with broad application in the corporate world. It is seen as the management approach of choice for dealing with an ever-shifting business environment....We have a much improved understanding of project management tools and techniques, and this decade has focused on the importance of the behavioral and organizational aspects of projects." Many authors concur with Wideman's view that we have developed a good understanding of the technical tools of the trade, while the past few years have illuminated the importance of

the behavioral, or soft, skills of project management.

The recent focus on the behavioral, or soft skills of project management is a realization by project management professionals that people and teams perform the work of projects. This realization has spawned much thought from authors that leadership is a significant aspect of project management. Covey (1989) states, "You manage things, you lead people." Drucker (2001, p. 81) echoes this thought, "One does not 'manage' people. The task is to lead people. And the goal is to make productive the specific strengths and knowledge of each individual." Eisner (1997, pp. 95-103) also appears to agree with this philosophy as he devotes an entire chapter in his text to "The Project Manager and Leadership." In this chapter, Eisner lists 20 attributes of a successful project manager. Fifteen of these attributes deal specifically with leading people. The balance of these attributes address personal management skills, which ultimately impact a manager's ability to lead project team members.

Along with the need for leadership skills, the Project Management Institute (PMI) recognizes the need for integration across all aspects of a project life cycle. The first of nine published Knowledge Areas in PMI's A Guide to the Project Management Body of Knowledge focuses on "Integration Management." This is the concept that a project manager facilitates the seamless delivery of a project from its planning and development stages, through project execution and completion, while also managing the scope and integrating change (PMI, 2000, pp. 41-49).

Kerzner (2001), Coates & Jarret, Inc., (1999), Haldane (1998), Pells (1998), Foti (2001), and many others see globalization, change and multinational project teams as the norm for projects in the future. They also seem to agree that the need for leadership, team building, and integration skills among project managers is becoming essential to successful project execution in this environment of global change. Thus, as the profession of project management

continues its evolution, it appears that leadership and integration are becoming much more important to project success - perhaps even more important than the tools and techniques which defined project management in the past.

Design-Build Project Management:

Design-build "...is a method of project delivery, which at its core posits a new relationship between owner and builder" (Belle, 2002, p. 1). It does so by placing responsibility on a single contractor to facilitate project completion all the way from initial concept stages through design, construction and sometimes transition, operation, and maintenance of the facility. Bearing the responsibility for all of these processes places more risk on a contractor and heightens the need for innovation, integration, and relationships with the owner in seeking to meet project performance requirements.

Design-build is not a new concept, but like project management its use has seen exponential growth over the past few years. It is rapidly becoming the construction management method of choice for markets and projects that require timely, cost-effective, quality, project delivery. More than ever, the norm within both public and private markets is change. Belle (2002, p. 1) states, "There is greater receptivity than ever to systems that can respond quickly and effectively to new market trends. Flexible, single-source delivery systems such as design-build are gaining increased market share precisely because they are best situated to respond to these emerging trends."

One of the inherent strengths of design-build is the ability of the contractor to shorten time frames and costs by running the design in parallel with construction. This requires involvement of the owner for decisions, providing them with more flexibility to make changes during each phase of the project. (Oberlander 2000). It also provides the contractor with more flexibility in "real-time" to attempt new delivery methods, try new materials, implement new technologies and better meet the performance requirements of the owner (USAGE,

1994, p. B-1). Many traditional construction delivery processes are without this advantage.

Design-build began to take hold as a single-source construction delivery system in the United States in the 1970's; since then its popularity has grown tremendously. The DesignBuild Institute of America (DBIA) predicts that design-build will overtake traditional design-bid-build delivery methods in the construction industry by the year 2005 (HBE, 2002). The DBIA itself was recently formed, in 1993, "in response to the emergence of design-build project delivery as a significant force in the design and construction field." (DBIA, 2002). Its emergence as a "significant force" came about because owners saw it as an integrated and innovative process that created a relationship, or partnership, with a single project delivery source. Halpin and Woodhead (1998, p. 72) believe this relationship is a "natural evolutionary step beyond the negotiated contract."

One example showing the need for owner involvement in design-build construction is illustrated by a study at Penn State University. This study used data from 351 U.S. building projects to show that design-build projects proved to be the most efficient of the current construction project delivery methods - with a caution that, in order for this to be true, owners must think and act differently than they have in past design-bid-build environments. From this study, Sanvido and Konchar (1999) conclude that design-build projects require owners to forge a team-centered relationship based on qualifications and best value to succeed. Since owners must be involved, it goes without saying that their project representatives must have the same abilities in their approach to managing a project.

The constructor led design-build methodology is based on integrating the design and construction elements of a building project to achieve better results. Planning for the ultimate construction phase begins long before the constructor

mobilizes on site. The greatest influence can be exerted during the project definition phase, and the ability to influence rapidly decreases as the project design continues. Project Management is the mechanism to control the process. Throughout the project it is very important to realize the close relationship between design and construction. The word design-build implies that design and build will occur simultaneously, and the processes can be viewed as an integrated system.

SUCCESS CHARACTERISTICS OF DESIGN-BUILD:

As with any goal or objective, in design-build there must be some measurable criteria to determine the ultimate success of the project. Most construction professionals would agree that a construction project would be considered successful if it were completed on schedule, within the established budget, according to the plans and specifications, and with zero accidents. However when you add the design-build approach there are extra dimensions that need to be measured. The six major elements of the design-build project consist of the project definition, preliminary planning, design, procurement, construction, and startup. The principle behind design-build is that all of the activities will be assigned to a single source to create a better overall project. The main advantages of using design-build are to establish and reduce cost, establish and reduce schedule, reduce and avoid claims, and to promote the use of constructability and innovation.

Owners like the fact that they can secure a fixed cost for a design-build project up front before detailed design has been started. This gives the owner the comfort and flexibility in knowing exactly how much money the project will cost. The fact that the design-build methodology fosters a well-defined scope early, means there will be less opportunity for scope related change orders and disputes, and the constructor can provide a GMP with low probability of surprises during construction. And because the constructor will assume all the risk, he will take a proactive approach at mitigating potential cost impacts

through all phases of the project, and particularly during the planning and design phase.

As owners like a fixed cost, they also like a fixed schedule. The design-build project establishes a firm schedule early in the project. Due to the fast track nature of the project, phased scheduling will allow the owner to occupy the building faster. Most of the schedule delays and time extensions in traditional construction stem from scope ambiguities and communication problems between the A/E and contractor such as permitting issues, RFIs, design errors, scope creep, design omissions, etc. In design-build these delays are avoided resulting in reduced design and construction time as well.

The design-build project protects the owner from claims. Not only does the design-build approach mitigate the risk of claims through increased efficiency and better overall communication and project coordination, the system also accepts full risk for design errors and omissions as well. The sheer nature of better relationships between designer and builder in the design-build approach makes this possible.

The next advantage is that design-build promotes constructability and innovation. The design-build project gives a great advantage of incorporating the constructors expertise and technical knowledge early in the planning and design phase. This process can prove to foster some of the most creative and innovative design solutions.

PROJECT DEFINITION:

The owner and the constructor must initially determine the functional needs of the project. A clear and concise project definition outlining the requirements with regards to cost, quality, schedule, building square footage, site logistics, circulation, performance objectives, commissioning, warranties, and aesthetics must all be established and documented before the design phase can

effectively start. This information is usually obtained verbally from meetings and compiled into a formal document known as the fitness for purpose. This report shall ensure mutual agreement of the project scope between the parties. Once the project definition is established the design-builder will prepare a cost model and schedule, which will further define the project. At this stage of development it is customary for the design-builder to include a contingency due to the many unknowns such as unforeseen site conditions. Likewise, it will be the constructor's responsibility to ensure the project stays within all the parameters defined by the fitness for purpose report as the project proceeds through design.

PLANNING AND SCHEDULING:

Once the project definition is established time is of the essence in the design-build project. Since one of the main selling points of the delivery system is the fast track nature, planning and scheduling are paramount. There are several important things to consider when planning and scheduling for this type of project. The most important aspect of achieving creative design innovation while maintaining the project budget and schedule is effective communication in the design construction partnership. The overall project schedule should include the major design deliverables, regular design review meetings and owner review and approval activities at the completion of each stage of design. And since one goal is to quickly get the project into construction, it will be important to make sure that the design is scheduled in a manner to allow for the procurement of long lead items and for the release of early site bid packages. Of equal importance and should be noted in the overall project schedule are the permitting processes. This would include planning and zoning approvals, EPA issues (wetlands, air quality), architectural review board approvals, and building park covenants, and the issuance of the necessary building permits.

CONSTRUCTION SITE ANALYSIS:

Since the general information about the construction site is available at the planning stage of a project, it is important for the constructor and design professionals to visit the site. Each group will benefit by firsthand knowledge acquired in the field. Since site work can be a major portion of the project, as well as possess unknown risk, there are many things to consider.

A primary concern should be the risk associated with unknown soil conditions. It is very important to investigate the subsurface conditions that will have an effect on the foundation design. The design-builder should determine that all site surveys and soils investigations have been completed and reviewed thoroughly. By analyzing the soil reports utilizing computerized techniques, the constructor can fully understand the risk associated with the project site and account for the required work within the estimate.

Also by carefully planning for construction logistics (i.e., staging, access to materials, personnel offices, equipment and hoists) during the design phase, construction productivity can be greatly improved. Potential problems will be avoided, and the site can be utilized to the fullest extent possible.

Additionally the constructor can offer insight as to the local construction economy. This can include advice as to the fabrication facilities and limitations that are available including; fabrication methods, transportation capabilities, labor conditions, and material and equipment availability. Typically this information is compiled into a report known as a Construction Market Analysis and contains the information from field visits, interviews, construction market conditions, and anticipated weather conditions.

DESIGN MANAGEMENT:

The design management process is similar to the construction management process in that teams of professionals work together to design the completed facility according to set budget and schedule parameters. Generally once the project

definition is established, the project will move through a series of design stages, including: the Master Planning Stage, Schematic Design, Design Development, and Construction Documents.

The purpose of the Master Planning Stage is to develop a narrative description of the specific function to be performed in each area of the facility.

Typically the narrative will segregate building spaces into departments with the corresponding square footage and quantity of spaces required.

Once both parties have accepted the design narrative, the Schematic Design phase will translate the written program stage narrative into single line drawings and outline specifications. Options for various structural and MEP systems will be selected. All major decisions for the new facility should be complete within this stage of design.

Next is the Design Development Phase. The objective of the Design Development phase is refinement and verification of the Schematic Design. At the end of the Design Development stage all decisions affecting the materials and systems should be finalized. Coordination of system interfaces must be resolved. Drawings and specifications should represent the intent of the Construction Documents.

The Construction Documents Phase is the final resolution and coordination of all design details, finishes and interfaces between project elements. At the end of this stage all documents and specifications required for permitting and competitive bidding to procure and construct the facility should be complete.

ESTIMATING:

Estimating in the design-build project is the primary means for cost control, and for this reason it is one of the most important functions in the process.

Typically after each phase of design, the design-builder will prepare an

estimate to make sure the design is consistent with the fitness for purpose report. The estimate will determine if there has been any scope creep in the previous stage of design. During each estimate, the design-builder may solicit appropriate subcontractor and vendor input for the current phase of design. A comprehensive estimating process is complex and beyond the scope of this paper. However, the most important key to remember is make certain quantities and pricing are accurate and in accordance with current market conditions. This will go a long way to ensure there will not be any surprises on bid day.

CONSTRUCTABILITY PLANNING:

Constructability planning has been defined as the optimum use of construction expertise during the planning, design, and construction phase of projects. During the design phase there are many areas where constructability planning can be utilized to save time and cost. Using off the shelf materials and components can save construction cost when comparable products are readily available. And by choosing configurations that simplify handling and erection, time can also be saved. By properly integrating construction logistics into the design, the whole construction process can be more productive, the overall project quality can be improved, and design errors and omissions can be avoided. Also through the incorporation of safety planning into the design, many hazards can be better safeguarded against.

TRADE CONTRACTOR PROCUREMENT:

It is common for a constructor to make a price and schedule commitment to an owner for a design-build project before detailed design is completed. And due to the fast track nature of the design-build project, the procurement schedule can drive the design schedule and erection sequencing. Some items to consider for early procurement include: retaining wall systems, heavy foundation systems, structural steel, pre-cast materials, post tensioned materials and systems, curtain wall systems, elevators/escalators, metal building systems, mechanical and electrical equipment and specialty construction systems. For

these systems it may be beneficial to award purchase orders and subcontracts early in the process, especially when there may be an early site bid package.

VALUE ENGINEERING:

Value engineering refers to the process of identifying unnecessary costs in design and construction and or proposing alternative design technologies to reduce cost without sacrificing quality or the intended performance requirements. Typically this process occurs at the conclusion of each stage of design, and new pertinent information is available for analysis.

A savvy design-builder will procure various sub-trades early and request their assistance with the design effort to take advantage of that particular trade contractor's knowledge and depth of organization.

In conclusion, there are many benefits achieved when utilizing the constructor led design-build methodology, which accounts for its growing popularity with Owners around the country.

Owner/client is a significant contributing party within the management of a project in construction. In addition to the payment of the bills related to the project, owner/client has duties and responsibilities such as selecting the professionals, making his requirements understood clearly by other parties, making decisions to recommendations and placing orders. Owner/client has to perform these duties and responsibilities at the right times and in correct ways to have the required quality and value for his/her investment. In performing his/her duties and responsibilities owner could introduce positive and negative contributions to the value of the constructed facility. Value-based project management concerns with owner's/client's value system and helps owner/client in performing his/her duties and responsibilities for the optimum positive contributions to the value of the constructed facility in

construction. This paper highlights the principles of value-based project management in construction and investigates the impact of owner contributions to the value of a constructed facility in practice. [PUBLICATION ABSTRACT]

Owner/client is a significant contributing party within the management of a project in construction. In addition to the payment of the bills related to the project, owner/client has duties and responsibilities such as selecting the professionals, making his requirements understood clearly by other parties, making decisions to recommendations and placing orders. Owner/client has to perform these duties and responsibilities at the right times and in correct ways to have the required quality and value for his/her investment. In performing his/her duties and responsibilities owner could introduce positive and negative contributions to the value of the constructed facility. Value-based project management concerns with owner's/client's value system and helps owner/client in performing his/her duties and responsibilities for the optimum positive contributions to the value of the constructed facility in construction. This paper highlights the principles of valuebased project management in construction and investigates the impact of owner contributions to the value of a constructed facility in practice.

A construction organization is an open system organization that accepts its input of human resources, materials, money, machines, all the information including owner's requirements, rules and regulations, and transforms them into a constructed facility (Pilcher, 1992, pp. 8-11). The owner-entrepreneur is seldom familiar with the details of the building industry; he is uncomfortable with the risk in the building cost projections; he wants to manage the expose within the narrowest limits available (McNulty, 1982, p. 32). Owner is a party who contributes significant input to the construction organization. Figure 1 shows a very general sequence of the operations that will take place when an owner seeks construction works. Actions by the owner are shown by single rectangular boxes, and those by the consultants in double frame boxes and those

by the contractors in boxes with rounded corners.

Owner therefore is not just an investor but also a significant contributing party within the organization. In addition to the payment of all the bills, owner has duties and responsibilities such as making his requirements understood clearly by the other parties, selecting the designers and advisers, making decisions in selection of contract options, selecting the contractors, making decisions to the recommendations and placing orders. Owner has to perform these duties and responsibilities at the right times and in correct ways and together with the best endeavors of the professionals and contractors, owner would have the required quality and value for his investment. The direct commitment of the client is one of the crucial determinants of success (Dodd, 1990, p. 394). Creative and innovative solutions are expected from client analysts, advisers, and consultants, from within and outside the construction industry (Smith and Love, 2001, p. 71). Because of limited human resources, owners have to re-evaluate both the timing and level of their involvement in the capital project delivery process (Anderson and Patil, 2001, p. 77). There are numerous alternative contractual approaches for the owner to choose to bring together interesting parties to form a team for design and construction of a project. In all types of the contractual relationships there are significant disadvantages adversely affecting the achievement of good management. As a result of this owners are suffering from many problems such as increasing costs, not getting the quality and value for their investment and dissatisfaction of the design and the finished product.

Implementation of a construction project is a complicated and complex process as it requires the contribution of different parties, successfully selecting best materials among a large range, using suitable methods and having capable labor and good supervision. Owner, whether public or private, is the initiating party that owns and finances the project, either from owner's resources or from external financing. The owners of the construction industry are many and

varied. They include the public sector bodies such as central and local government and private companies involved in building for domestic, commercial, industrial and retailing purposes (Clough, 1981, p. 3).

First requirement of the owner is to establish his needs and objectives and clearly express them to other parties. This provides a focus for scope definition, guides the design process, and influences the motivation of the project team. The process of setting objectives involves an optimization of quality, cost and schedule. Owner's objectives must be clearly communicated and understood by all parties, and serve as a benchmark for the numerous decisions that are made throughout the duration of the project. The process of identifying owner's needs and objectives require the involvement of a wide range of people within the owner's organization (Oberlender, 1993, pp. 20-21). Owner must clearly develop or agree to a delineation of the responsibilities borne by all members of the project team. Each must understand his/her own responsibilities as well as the extent of responsibilities delegated to the others (Barrie, 1992, p. 171).

Owner's major duties and responsibilities in construction are:

- * Identifying his/her requirements and objectives.

- * Expressing clearly his/her requirements and objectives to the other interesting parties.

- * Determining the overall project budget.

- * Selecting designers, advisers and contractors.

- * Making decisions to the recommendations.

- * Providing coordination for the project.

- * Making the final decisions.

- * Setting criteria about total budget, payments and project end date.

- * Placing orders.

- * Paying all the bills as per the requirements of the project.

In construction management, owner therefore is not just an investor but also a significant contributing party from the concept till completing stage of a project.

Field surveys on owner's factor in construction show that:

- * Most of the owners need help in understanding technical explanations and in expressing their requirements to the professionals. In making correct decisions owners need understanding of basic construction details.

- * Owners (93%) confirm that their participations introduce positive effects on the value of a constructed facility.

- * All experts agree that owner's involvement in the management of a construction project is required.

- * The majority of the owners acknowledge that making final decisions, selecting professional parties, selecting materials and paying the bills are within their duties and responsibilities.

- * Experts claim that owner's lack of knowledge of details of building industry

adversely affects owner's decisions.

* Most of the owners (89%) and most of the experts (67%) agree that owner needs to appoint a facilitator/value-manager to oversee the implementation of the project.

* The majority of the experts (83%) agree that facilitator/value-manager can improve owner's contributions.

* Only (47%) of the owners are satisfied with the constructed facility.

The duties and responsibilities of the owner in the implementation of a construction project is highlighted. Owner has to perform important duties and responsibilities at the right times in correct ways during the implementation of a construction project. Owner needs to understand basic construction details. Surveys show that, in practice, owner has difficulties and needs help in performing his/her duties and responsibilities for positive contributions to the value of a project. Being an owner-oriented approach, value-based project management can help and direct owner in performing his/her duties and responsibilities to maximize the functional value of a constructed facility based on owner's value system.

Quality management knowledge is now one of the many technical competencies required by a Construction Project Manager. Owners and customers are becoming more quality oriented, and expect extended design and service life of constructed products. This leads to a greater focus on quality management to achieve the requirements. Customers may also expect contractors to take a larger role and more responsibility in construction quality management, especially in DesignBuild projects.

Barriers to implementation of a construction quality management system

identified by Loushine (2003) include:

- * Lack of management commitment and leadership
- * Poor understanding of customer expectations
- * The nature of construction
- * Lack of worker empowerment or incentive, worker attitude and awareness
- * The multitude of parties involved in the construction industry

The last point illustrates that achieving quality in construction requires a collective effort from all participants in a construction project including the customer, designer, contractor and suppliers. Based on the industry challenges described earlier the list of barriers could be expanded to include insufficient funds to support improvements and a tradition based industry slow to accept change. Construction industry firms may also be challenged by other priorities including business survival, focus on requirements that can have significant financial and legal impact on company managers such as environmental and safety management and keeping pace with technology changes.

Contractors, engineering and project management firms that have implemented an quality management system based quality system have reported benefits including:

- * Reduced rework
- * Improved productivity and control of key processes including project cost, schedule and performance objectives

* Documented processes that allow easier training of employees, aiding in succession planning

* Reduced professional liability insurance claims that offset the QMS development costs

* Improved records to justify changes in work scope

* Streamlined business practices and development of management tools to monitor and maintain continual improvement.

* Access to international project work

Conclusion:

This paper showed how the application of total quality management principles in the construction industry can result in many benefits. Such as more customer satisfaction, less work recycle, less cost of poor quality, less schedule delays, and future project prospects with the client. The paper highlighted the difficulties encountered during this process of applying total quality management in these design-build projects and the learning and saving realized.

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