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The *Journal of Construction Education* (ISSN 1522 8150) was founded in 1996 by the Associated Schools of Construction, an association of 92 international colleges and universities with construction education programs. The purpose of the *Journal* is to provide an important process necessary for the preservation and dissemination of manuscripts that report, synthesize, review, or analyze scholarly inquiry. The *Journal* is an important way of our focusing international attention on and contributing to the understanding of the issues, problems, and research associated with construction education and training. The recognition of scholarly work within the realms of curriculum information, contemporary educational practices, educational research and instructional application development within construction departments, schools and colleges, and industry are the reasons for the *Journal's* existence. The *Journal's* mission is to provide construction educators and practitioners with access to information, ideas, and materials for improving and updating their understanding of construction education and training. It is also intended to help its constituency become more effective in developing the talents of learners within construction programs. This *Journal* is not only a living textbook of construction education, but also a perpetual and dependable learning source for construction professionals whether they are within academia or within industry. The *Journal* will be published tri-annually (Spring, Summer, and Fall issues). The divisions of the *Journal* include invited and editorially reviewed Book Reviews and Teaching Profiles, and blind peer reviewed Educational Practice and Research Manuscripts.

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Editorial
Annual *Journal* Entries

For the past year and a half, I have worked to make the *Journal* the best electronic publication available to construction faculty. I believe this has been achieved, although it will probably need to be modified some as the quality, numbers of submissions increase and the technologies of electronic publication changes. I will briefly provide a description of Journal progress through this entry. In that this was not done in the first volume this entry will encompass both the 1996 volume and the 1997 volume.

Short History

In April of 1996 the Associated Schools of Construction's (ASC) Board of Directors approved the *Journal* as the educational manuscript publication outlet for their member's faculty. There was uncertainty within the Board if the ASC's membership could support a journal through an effective number of submissions. Therefore, they placed a requirement that the 1996 and 1997 annual conference proceedings papers be grandfathered into the Journal. This policy decision did not accurately reflect the current Editor's publication corpus. As a result the manuscripts during these two years were not submitted to the *Journal's* Board of Reviewers. This does not mean that the grandfathered manuscripts were not subjected to a blind review. The papers within the ASC Annual Conference Proceedings do go through the blind review process. There is a difference between these reviews. The proceedings review process includes discussions between the reviewer and author prior to the vote. This process is meant to provide a dynamic interaction between practiced reviewers and often novice authors that makes available a means of faculty development. The *Journal's* review-submission process represents one of manuscript finality. It is expected that the author is submitting a final manuscript ready for publication. It is also *Journal* policy to encourage authors to have had their current submission processed through the review of the Annual Proceedings. In some circles, this would constitute a double-blind review for manuscripts published within the *Journal*. Four reviewers would have had to accept the manuscript rather than just two. It is expected that this would only enhance the quality of the *Journal* and would support the ASC's mission. One of the most significant contributions that the ASC provides its membership is collaborative support dedicated to the development of junior faculty. To this end the *Journal* is fully dedicated.

Vital Statistics

Average number of pages per published manuscript. In the first year the manuscripts averaged 8.9 pages while the second volume averaged 10.55. It is apparent that the number of pages per published empirical manuscript is on the increase. Are the authors simply adding fluff in current times? The Proceedings is limited to fifteen pages, so one cannot consider it as a constraint. I believe instead that authors are generally having more thought-provoking and exciting information to offer. I believe that the underlying theoretical rationale for their work and resulting speculations about the empirical outcomes of their work is evolving. If one would take note, within construction academia it no longer is sufficient to have industry experience to be a construction educator. One must also have the academic credentials to provide certification of their learning and teaching abilities. We must be careful as educators to insure that an industry credential does not take precedence over the academic credential. However, we must also guard against faculty not having real world experiences to bring into our classrooms.

Average number of images, tables, and appendices. There was no significant difference between the two volumes with relation to images, tables, and appendices. Tables averaged 2.28 and appendices 0.53. The images averaged 1.6, which I believe will change to a greater value as the authors begin submitting to the electronic journal. I feel strongly that images assist in communicating concepts much better than text and with the *Journal's* graphic interface and lack of length restriction these numbers will increase. The *Journal* represents a unique communication tool that avails modern communication technologies to its authors. As the *Journal's* Editor, I will encourage, exciting, and guide faculty to utilize that which has been made available to them to the best benefit of the readership.

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Excavation Support Systems for Construction Operations

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Excavation support systems are temporary structures that have a fundamental influence on the safety, quality, speed, and profitability of construction projects that require deep excavations. Despite their great importance, most contractors and members of the construction industry know very little about their design and construction. There is far less technical guidance available for the design of excavation support systems than for permanent structures, or even than for more common temporary structures such as framework. Designers and builders of excavation supports rely heavily on past experience as well as company-specific design and construction guidelines to perform their work. This leaves owners and general contractors somewhat in the dark when it comes to making decisions about excavation support systems. There is a need within the construction industry to clearly define the nature and scope of excavation support systems, and to identify what technical guidance is available for their design, erection, maintenance, and removal. Educating owners and contractors about the current state of practice regarding excavation support systems will improve their ability to work and make decisions with the specialists that they hire to design and install excavation supports. The goal of the research presented in this paper was to perform a literature review of published work in the United States and survey US design firms to identify the current state of the practice in the support of excavations and to identify any inadequacies in present knowledge. A brief review of the systems available for the support of excavations along with the results of the survey of US design firms is presented.

Key words: Temporary Structures, Support of Excavations, Soil Nailing, Survey, Guidelines

Introduction

Excavation supports structures include all means and methods of preventing a collapse of the earth walls that surround an open excavation. Excavation support is an issue of extreme importance to construction safety officials due to the serious threat to life posed by a potential earth cave-in. OSHA has mandated that any excavation or trenching operation that goes 5 or more feet below ground level must utilize an acceptable excavation support technique.

Usually the cheapest and simplest way to support an excavation is to slope back the sides of the excavation to the acceptable angle of repose. OSHA standards clearly indicate to what depths and at what angle of repose a contractor may perform an excavation. These requirements are dependent on the contractor identifying the soil properties of the area to be excavated, so that suitable angles of repose can be determined. As long as the excavation is not too deep, and adequate space exists on the site for the sloping to occur, contractors will generally opt to support excavations in this fashion.

The subject of excavation support becomes much more complicated when deep excavations take place and there is no room to slope back the soil to the required angle of repose. In this type of a situation earth retention systems must be designed which meet the specific requirements of the site and soil conditions. This occurs most frequently in urban settings where tall structures with deep foundations and basements are constructed on sites constrained by adjacent buildings. The issue of excavation support becomes further complicated when excavations may undermine the structural integrity of nearby foundations. The resulting need to underpin the foundations of adjacent buildings becomes the responsibility of the contractor in most cases. Underpinning can either be a separate activity, or can be combined as an integral component of the excavation support structure.

Although there is no universally accepted definition of shallow or deep excavations, this paper will make the distinction between the two at a depth of twenty feet. Twenty feet is generally the limit to which OSHA will allow an excavation to be sloped, or for the contractor to use a trench box. Excavations greater than twenty feet often require an engineered support system. Several design solutions exist for the problem of excavation support, and these solutions will be categorized and explained later in this paper.

Lack of Unified Design Philosophy

Excavation support is the category of temporary structures with the greatest need for technical guidance. An equal or possible greater amount of literature exists on subjects related to excavation support than any of the other temporary structures categories. However, this material is scattered, and the construction industry seems to lack a unified design philosophy for excavation support structures.

The reason for this lack of a unified design philosophy may be the tremendous variety of solutions that can be applied to an excavation support problem. The sheer number of variables makes it hard for a person to decide what approach to take. Codes and project specifications are also of little help.

Four building codes, The National Building Code, the Uniform Building Code, the Southern Standard Building Code, and the South Florida Building Code were reviewed as to their content on excavation support. None of the four offered any specific guidance for design. Nor did they reference the reader to other applicable technical guidance. They simply require the designer to provide safe access and support for excavations.

Excavation support system designers tend to rely most heavily on their past experience. They are also aided by civil engineering and geotechnical texts, manufacturer’s literature, and in the cases of large design-build firms, in-house data. There seems to be no consensus on what sources are needed for the design of excavation supports.

Conventional Systems for the Support of Excavations

Excavation support structures can be divided into three basic categories:

1. Cantilevered Systems

2. Braced Systems
3. Tied Back Systems

Each category has certain advantages and disadvantages, depending on the depth and soil type of the excavation. Builders and designers should be familiar with the variety of systems that are available, so that the best support structure will be utilized every time a deep excavation takes place. Generally, cantilevered applications are used for shallower applications, but in special instances can cover up to fifteen meter (fifty feet) in depth. Braced and tied back systems are used for greater depths where a cantilevered or embedded wall alone is not enough to overcome lateral earth and water pressures (Schroeder, 1984). It is very common for individual support systems to combine characteristics of all three general types. For example, a cantilevered diaphragm wall could be tied back or braced for additional support.

Braced Sheeting

Braced sheeting includes skeleton and continuous sheeting. Skeleton sheeting is a timber application, while continuous sheeting is almost always of steel.

Skeleton Sheeting

Skeleton sheeting can only be done in somewhat cohesive soil and above the water table. The structure resembles the layout of wall forms for cast-in-place concrete. Wooden uprights are spaced vertically along the wall of the excavation and are held in place by horizontal walls backed by braces or struts. Skeleton Sheeting has very limited load-bearing capacity and lacks a standard, defined procedure (Koerner, 1984). Its applications are limited to relatively shallow cuts.

Steel Sheet Piling

Steel sheet piling consists of continuously driven, interlocking steel sections that form an earth retaining wall. These structures can be made watertight, and are therefore very common in marine applications. Steel sheet piling requires an expensive initial investment and very costly pile driving equipment (Illingworth, 1987). Due to its cost and unique requirements, steel sheet piling is one of the most specialized areas of construction. Design specifications and guidelines are generated from within the sheet piling industry. Companies such as Pile Buck, based in Jupiter, Florida, have produced state of the art manuals that describe the various uses, design, and installation of sheet pile walls. The ability of steel to take on different shapes and thicknesses, and to behave at different levels of flexibility, causes steel sheet pile design to be unique from any other type of excavation support structure. Sheet pile walls can be cantilevered, anchored with tie backs, strutted, or a combination of any of these. Cantilevered walls are typically restricted in height to about 4.5 meter (14 feet). This is due to the deflection experienced by the top portion of the wall and the large embedment lengths required to overcome active earth pressure. Anchored sheet pile walls utilize both the passive pressure of the embedded portion and of tie rods near the top of the structure. They are recommended to heights of about 10.5 meter (35 feet). Braced walls are used for the deepest applications. In this method, struts are utilized to handle lateral loads from two opposing sides of an excavation (Pile Buck, 1987).

Soldier Piles and Lagging

The soldier pile and lagging method is one of the oldest and most widely used methods of excavation support in the construction industry. The systems are basically configured of steel H-sections or I-sections that are placed in the ground before excavation ever begins. As the excavation proceeds downward, the exposed earth walls between the piles are sheeted with boards or other suitable materials. The allowable excavation which can take place before the operation must be stopped and sheeted depends on the soil type. In sandy soils the sheeting must be nearly continuous (Illingworth, 1987).

Slurry Walls

Slurry walls are continuous concrete walls that are built beneath ground level before an excavation takes place. They are typically cantilevered systems, although it is possible for them to be braced or tied back as well. The guiding principle behind the construction of slurry walls is that bentonite slurry or driller’s mud immediately replaces the soil that is dug out for wall sections, ensuring that the trench will not collapse before it can be filled with concrete. Concrete is pumped through a tremie starting at the bottom of the wall, and displaces the bentonite slurry as it reaches the top. Sometimes structural requirements call for the placement of reinforcing steel before the wall is poured. The end result of this process is a continuous concrete earth retaining structure that is embedded deep enough below the proposed level of excavation (and/or braced) to resist all resultant lateral pressures. The slurry wall supports the sides of the excavation and often is abandoned in place, or integrated into the permanent structure.

Slurry walls are the most versatile means of excavation support, because they can be used in any soil and to virtually any depth, limited only by machine capabilities (Hajnal, 1984). They serve a variety of functions, potentially providing sheeting, waterproofing, and load bearing all in one structure. Slurry walls can also be constructed in a great many shapes and in varying site conditions. For instance, slurry walls can go in diagonal or curved patterns, and can be built right along side an existing structure. Another benefit of slurry walls is that they do not clutter the site with braces and supports that get in the way of construction.

Despite their versatility and functionality, slurry walls are expensive and complicated structures to build. There are difficulties in containing the bentonite slurry, which has a soupy consistency, and keeping the site neat and pollution-free. The slurry also prevents direct inspections of the walls before they are poured. The construction process requires very costly excavating and pumping equipment, and the wall components cannot be reused, as is the case with some other systems. Slurry walls, also called diaphragm walls, are the most economical solution only when dewatering is involved or when no other solution is feasible (Hajnal, 1984).

Continuous Piling

Continuous piling is an example of a foundation technique that has been adapted for excavation support. Like slurry walls, continuous pile walls are often integrated into a project's permanent structure. The idea behind continuous poling is that standard bored piles can be placed close enough together that they will form a solid wall. The piles are machine augured and poured with concrete before excavation begins. In some cases the secant piling method is used. This is where adjacent piles actually cut into each other to form a watertight wall (Illingworth, 1987).

Underpinning and Dewatering

Underpinning and dewatering are two additional considerations, which often affect the excavation support design process. Underpinning becomes an issue when an excavation occurs near an adjacent structure. Common in urban settings, underpinning involves the stabilization of nearby foundations to prevent any damage resulting from new construction. Some of the methods of excavation support previously discussed perform underpinning functions as well as earth retention. These methods include slurry walls and continuously piling.

Dewatering becomes an issue any time an excavation will proceed below the ground water table. Two basic solutions are available for ground water control. The first is to select a watertight support method such as continuous steel sheet piles or slurry walls. The second option is to temporarily or permanently alter the level of the water table. A common way of accomplishing this is through the use of a well point system. Well points are a series of wells and pumps placed around the perimeter of an excavation that draw water away from the work.

Survey of United States Design Firms

Construction is a profession that is grounded deeply in practical applications rather than theories and books. In order to truly understand the current practice in the design of excavation support structures, it was necessary to go beyond published literature and obtain input from the working professional world. The first challenging step in this process was to identify which design firms around the country are specialized in the design of excavation support systems. After identifying the sample group, a survey was written and piloted. The goal of the survey was to determine the current state of practice in design of excavation support systems in construction, and to identify what research and development should be carried out.

Locating the Survey Sample

The design of excavation support systems remains one of the most specialized areas in the engineering and construction fields. It requires a complete understanding of soils, geotechnical forces, and unique structural requirements. In addition, excavation support almost always involves a certain amount of risk based on the unknown, because subsurface conditions are difficult to predict with complete accuracy. For these reasons and others, very few companies around the country deal with the design of deep excavation supports. Since no comprehensive list of excavation support specialists exists, locating these companies was a matter of trial and error at first.

The process began by making telephone contact with individuals found on the American Society of Civil Engineers' (ASCE) listing of structural engineers. Most of the ASCE members were not themselves designers of excavation supports, but provided excellent references to firms who were. Each firm contacted was usually able to provide other references. Through this process of telephone networking, a national listing of over 30 specialty firms and designers was compiled.

Developing the Survey

There were three main objectives of the survey developed for this project:

1. Determine current practices in the design of deep excavation supports;
2. Identify which sources of technical guidance are being used, and determine if the amount of available guidance is adequate; and,
3. Determine what research needs to be carried out in the area of excavation support design and/or construction.

A seven-item questionnaire was written along with a short cover letter explaining the nature of the research project and the goals of the survey. Before being sent out to the list of designers, the survey was piloted and reviewed based on the following criteria: clarity, focus, time, and codability. The final copy of the survey contained brief instructions and clearly stated its purpose. It was designed to be completed in 5 to 10 minutes, and to provide easily interpretable data.

Analyzing the Results

The overall conclusion that can be drawn from the results of the survey is that very few people in the United States are routinely designing excavation support systems; but hose who do, feel that there is generally enough technical guidance to meet their design needs (see Figure 1). It was also the consensus opinion of those surveyed that an engineer's pervious experience is the most important resource that he or she has for the design job (see Figure 2). The largest firms surveyed, such as Hayward Baker and Haley and Aldridge, indicated that they actually produced and used in-house design standards and criteria. The survey indicated that the designers of conventional support systems, such as slurry walls, soldier piles and lagging, or sheet piles with tiebacks, are not in need of improved technical guidance. Adequate materials already exist to meet their needs.

Question three of the survey asked designers to rank the factors that determine which type of excavation support system they will choose in any given situation. The responses to this question clearly indicated that safety is the most critical issue. Cost and technical feasibility were the next most important considerations. The results of this item are shown graphically in Figure 3. Respondents listed what they thought were the most pertinent research topics to their field. The 20 suggested topics are listed in Figure 4. Each of these topics were reviewed by the research staff to determine its feasibility for further pursuit. It was decided that all topics that required in-situ testing or expensive laboratory equipment would be eliminated. Other suggested topics were eliminated based on a lack of continuity with the original research goals. The topics that remained after this elimination process were numbers 2, 3, 7, and 14.

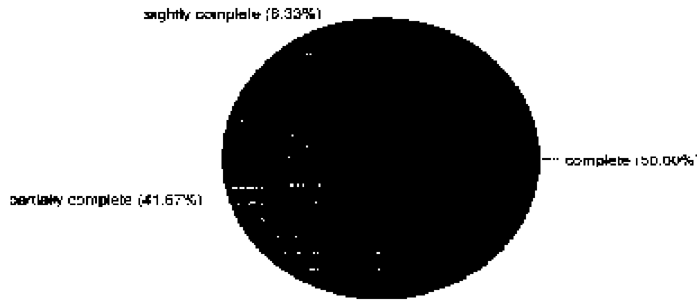

Figure 1. To what extent does the amount of technical guidance currently available to designers meet their needs?

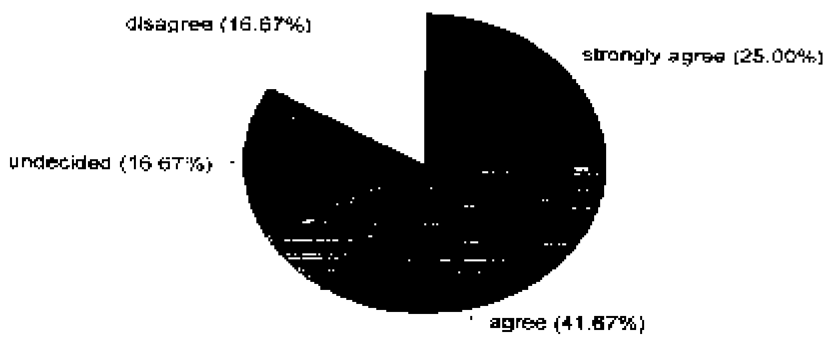

Figure 2. Is previous experience the most important factor or resource available to the designers of excavation support systems?

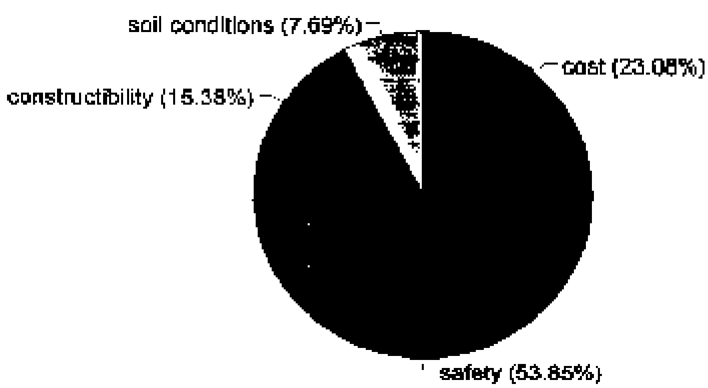

Figure 3. What are the most important factors in selecting an appropriate excavation support system for a particular project?

1. Underpinning methods combined with excavation support.
2. Combining excavation support with ground water control.
3. Designing more rigid support systems (such as soilcrete or grouting) as compared to more flexible systems such as soldier piles or sheet piles.
4. Load distribution data trough walls and support members.
5. Performance data vs. design estimates.
6. Behavior of system below excavation level (deformation of toe of system).
7. Integral discussion of costs vs. risks between members of design and construction team.
8. What are acceptable factors of safety?
9. LRFD design methods.
10. What are acceptable levels of overstress?
11. Areas of overconservation supported by case histories
12. Should designs include seismic loads?
13. Quality (adequacy) of site soil explorations.
14. Practicality and safety of alternate shoring techniques (soil nailing, soil freezing,…).
15. Distribution of loads to anchors for multi-level anchor walls.
16. Accounting for arching behind soldier piles in pressure load determination.
17. Problems with contractor designed (non-professional engineer) systems.
18. In-situ field testing to determine design vs. actual fidel response of support systems.
19. Obtaining good horizontal subgrade information to better model realistic movement.
20. Developing a "cook book" approach for design.

Figure 4. Suggested research topics

Following-up the Survey

Each of the designers who's suggested topics were chosen for further review were interviewed by telephone. The engineers explained the intent of their suggestions in greater detail to aid the research team in selecting one out of the four possible topics. The details of these discussions are outlined in the following section.

Topics 2 and 3

An engineer from Hayward Baker suggested focusing on two ideas. The first was issue of combining excavation support with ground water control. This becomes a key issue when the owner of a project, a municipality for example, does not want to allow dewatering to take place. Possible reasons for this would be the fear of unacceptable settlement around existing buildings or environmental concerns such as ground water withdrawal and recharge. The engineer stated that a technical guide which advises designers on the specific approaches which should be taken when excavation supports are required to control ground water would be very helpful to the industry.

The second topic which was discussed with the Hayward Baker engineer was researching the use of rigid support systems as opposed to more conventional flexible ones. This becomes an issue primarily when excavation supports must also perform as underpinning structures. Flexible systems such as steel sheet piling or soldier piles and lagging are not capable of supporting overhead structures. Conventional rigid systems that have underpinning capabilities include slurry walls and bored pile walls. It was suggested that the underpinning value of less conventional rigid systems, such as soilcreting and grouting be researched.

Topic 7

A designer from Haley and Aldridge suggested an integral discussion of costs versus risks between all members of the design and construction team. This designer feels that the tremendously high cost involved with the support of deep excavation is causing the industry to move toward more risk-based solutions. What this means is that owners are having to decide how much risk they are willing to accept in order to control the costs of a given support system. This has a lot to do with defining the parameters of system failure, and determining what type of specifications to place on a system.

An example of cost/risk issues that owners, designers, and contractors might face would be specifying the allowable movement of the toe of an embedded support wall. Cantilevered systems resist active earth pressures through the passive pressures generated in their embedded portions. Designers are aware that the toe of a cantilevered system almost always experiences some movement. The safest and most expensive option for the owner would be to specify minimal or no movement in the toe of the system. This is also the best case for the designer who must assume liability for his or her design. However, such a specification might be prohibitively expensive. The goal of the research topic suggested by the Haley and Aldridge engineer would be to discuss what trade-offs between cost and risk would be acceptable. This type of a project would have to include case studies where the cost vs. risk issue actually came into play.

Topic 14

The topic suggested by an engineer from Ed Waters and Sons was the one that was eventually selected for the further research on this project. His suggestion was to conduct a comprehensive review of the available guidance, practicality, and safety of alternate shoring techniques. These techniques include soil freezing, soil nailing, grouting, and geosynthetics. The engineer explained that while these techniques may theoretically be cheaper or better options than conventional systems, they must be carefully studied before being used. A soil freezing systems used on the King's Bay project in Jacksonville, Florida, for example, failed badly due to poor planning and design. Soil nailing was chosen out of all of the possible alternate shoring techniques that could have been studied. There were three main reasons for this decision:
Soil nailing has been used for many years in Europe and is becoming increasingly better known and accepted in the United States.

Soil nailing, more so than the other techniques, is generally used only as a temporary support.
No standard design, construction, or inspection guidelines currently exist in the United States for soil nailing.

New Systems for the Support of Excavations

The introduction of ground anchors and tied-back walls in the 1950's and 1960's served as a catalyst to the development of innovative new systems for the support of excavations. Element walls were introduced that utilized precast or CIP concrete units with tie backs, allowing wall construction to take place simultaneously with excavation. Next, gravity walls were developed that introduced the concept of using reinforced soil or earth as a structural element. The continuation of this process led to the development of soil nailing which employs the soil mass as its main structural element. The advantage of soil nailing over gravity walls is that soil nailing is top-down procedure as opposed to bottom-up process (Stoker and Riedinger, 1990).

The two most notable trends in the industry over the past twenty years are:

1. the increasing use of reinforcing elements to create reinforced soil; and
2. the increasing use of polymeric products to reinforce and control drainage in soils (O'Rourke and Jones, 1990).

Soil Nailing

Soil nailing, like the other systems described in this paper, is a method of supporting the walls of an excavation. The primary difference between soil nailing and these other conventional systems is that soil nailing stabilizes the sides of an excavation through in-situ reinforcement of the soil (Chapman, 1990). For this reason, it is classified as an internally supported system. Systems such as soldier piles and lagging or slurry walls must overcome earth pressures with external structural walls, while soil nailing stabilizes a soil mass by placing reinforcements in and through the potential failure mass of the soil (O'Rourke and Jones, 1990). Soil nailing actually increases the overall shear strength of the soil, restrains its displacements, and limits its decompression (Juran, 1987). This is accomplished through the use of tension elements that are driven or drilled and grouted into the ground. The reinforced ground becomes the system's primary structural element, with a layer of shotcrete applied to support the face of the soil nailed wall.

Since soil nailing is rapidly gaining acceptance in the United States, it is important that engineers and contractors understand how these systems are used and what technical guidance is available for the design and construction of these systems.

A Brief History

Since 1970 the field of excavation support technology has experienced a major increase in the use of reinforcing elements and internally stabilized systems. Soil nailing is generally thought to have evolved from the processes of rock bolting and the New Austrian Tunneling Method. It has become prevalent in France and Germany and is rapidly gaining popularity in the United States. The first recorded use of soil nailing was for the stabilization for a railway cut in France in 1972. The method arrived in the US in 1976, when it was used for the temporary support of a hospital basement cut in Portland, Oregon. By the 1990's soil nailing accounted for 5 to 10 percent of all of the in-situ excavation support construction in the US (O'Rourke and Jones, 1990).

The Function of Soil Nailed Walls

Soil nailing has three major functions within the construction industry. Soil nailed walls have been primarily used to support excavations for both general building construction and highway and heavy construction. The method is thought to be most applicable in cases where tied back walls have been deemed an appropriate means of support. Walls have been constructed to depths of 30 meters (100 ft.). Soil nailing can also be used in the repair and reconstruction of existing structures. Additionally, soil nailing is used for slope stabilization. This final function includes the stabilization of creeping slopes and unstable slopes (Elias and Juran, 1991).

Why Use Soil Nailed Walls?

Soil nailing provides the construction industry with an economical option for the construction of in-situ walls for excavation support. In addition to cost savings of up to 30 percent over more conventional systems, soil nailing offers several advantages including adaptability and technical benefits. Some of the technical advantages of soil nailing compared to conventional systems are listed below:

- requires only light equipment;
- the number of individual nails is so great that failure of one or two is not critical;
- nail diameters are small which makes drilling into rocky soil much easier;
- the system is relatively flexible and can withstand some ground movement; allows for the control of surface deflections (Elias and Juran, 1991).

The Components

As stated previously, the reinforced earth mass is the primary structural element of a soil nailed wall. The soil is reinforced by passive inclusions, or nails, which resist tensile stresses, shear stresses, and bending moments. Nails are generally steel rods or bars of 343 MPa (50 ksi) yield strength, 15 to 46 millimeter (0.6 to 1.8 inches) in diameter. A continuous shotcrete facing is applied to the outside face of the reinforced soil mass to stabilize the ground between the layers of nails. Each nail is attached to the facing by embedded steel plates, cladding, or other methods.

The Construction Process

The basic construction sequence for soil nailed wall is illustrated in Figure 5. It is a top-down process that involves excavation to a specified depth, installation of nails, application of facing, and further excavation. Of course, the presence of groundwater and use of complicated techniques add many more involved steps to this process. The depth of cut which is permissible before the installation of nails and facing depends on the properties of the soil mass. In some cohesive and rocky soils, cuts of approximately three meters (10 feet) can be made preceding in-situ wall construction. Less stable soils such as sand can only be excavated to a depth of about 1.5 meters (5 feet) before the process must be stopped and the soil nailing performed. Very unstable soils may require the placement of shotcrete before the nails are installed. Each section or layer which is excavated and nailed becomes linked to the surrounding sections, and the entire soil mass becomes an interconnected, stable system.

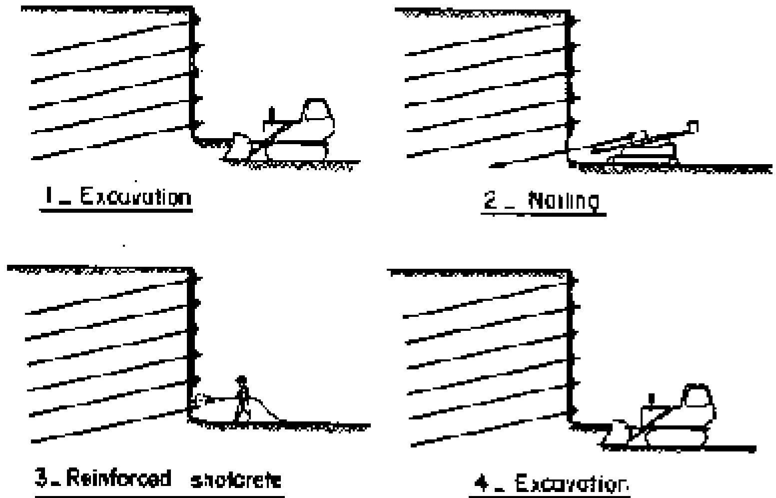

Figure 5. Basic soil nailing process.

Design Methods and Available Standards/Guidelines

One of the difficulties for owners who wish to specify the use of soil nailing is their projects is the lack of universally agreed upon or accepted design process. The three most extensive users of soil nailing, the United States, France, and Germany, each have their own preferred methods. The Germans primarily use a limit analysis method developed by Glassler, et. al. The French use the TALREN or multi-criterion method developed by Schlosser. In the United States the predominant design procedure is the Davis method (Elias and Juran, 1991).

There are several app[roaches to designing soil nailed retaining structures. Each method has been successful at achieving the chief design concern of soil nailing: to ensure that the soil-nail interaction is effectively mobilized to restrain ground displacements and ensure structural stability within an appropriate factor of safety (Elias and Juran, 1991). The industry has not, however, reached a consensus conclusion over the issue of which method is the safest and most effective for given design situations. Furthermore, no general design or construction guidelines currently exist within the United States.

The Federal Highway Administration published a report in 1991 that recommended a design practice that combines several different methods. In addition to recommending design procedures, the report also includes an appendix of construction guide specifications for permanent soil nailed structures. While this report represents the most comprehensive work on soil nailing to date in the United States, it does not qualify as an official adopted design or construction guideline. Clearly, the next step which must be taken in the field of soil nailing is the development of such a standard or guideline.

A recent interview with an engineer from Schanbel Foundations revealed that the Federal Highway Administration (FHWA), in conjunction with the American Association of State

Highway Transportation Officials (AASHTO), has undertaken the project of developing comprehensive design, construction, and inspection guidelines for nailing. In addition, the FHWA project will be developing an educational curriculum to train employees of the agency on the various techniques involved with soil nailing. According to the interviewee, the project is one of the most complete and well-executed undertakings of its kind.

As of the writing of this paper, there is no scheduled date for adoption or publication of the design, construction and inspection manuals. However, the project is well underway and sources working closely with the FHWA claim that the manuals that are being prepared will meet all needs for technical guidance for the design and construction of soil nailed retaining structures.

Soil Grouting

Soil grouting, like soil nailing is quickly gaining acceptance in the United States and is experiencing a rapid increase in use for the support of excavations. There are several varieties of soil grouting, all dealing with the additions of high strength grout to stabilize soil masses. The major classifications of soil grouting include cement grouting, compaction grouting, chemical grouting, and jet routings. Jet grouting is the technique most commonly used in the support of excavation. The other methods are more commonly used for underpinning or foundation improvement.

Soil Freezing

Soil freezing is an innovative technique which utilizes refrigeration pipes to effectively freeze the soil into one solid, stable mass. In cold climates and in situations where only short term excavation support is required, soil freezing is a viable option. Two other important benefits of soil freezing are its ability to halt the flow of ground water and cut off the movement of toxic waste through soil.

Conclusions and Recommendations for Further Research

The investigation performed for this research project showed that adequate technical guidance exists, or being currently developed, for the design of excavation support systems. While approved standards do not exist for the design of excavation supports, specialty engineers feel that they have the resources they need to produce safe designs. Design, construction, and inspection guidelines for soil nailing are currently being developed by the Federal Highway Administration (FHWA). These guidelines will meet the need that currently exists within the industry for improved standards and guidelines for soil nailing.

One of the important conclusions of this project is that the design of excavation support systems is a very specialized field and needs to be performed by an experienced engineer. Most of the large companies working in this field handle the work on a design-build basis, and often use their own in-house design criteria. Any owner or contractor who is considering the construction of a deep excavation support structure needs the service of a geotechnical engineer and specialty contractor, because "design-it-yourself" guidelines do not exist, like they do for other temporary structures such as formwork.

One topic that is becoming increasingly relevant is the questions of whether owners should provide prescriptive or performance specifications. With the upcoming publication of FHWA's design manual for soil nailing, it will be possible for state and federal agencies to provide the design specifications of a soil nailed wall in a construction project's bid documents. The other option open to owner is to leave the responsibility for designing the excavation support system to the contractor, and provide only performance specifications. In this latter case, the soil nailing design manual would simply become a resource or option, not a required guidelines.

There are several advantages and disadvantages to owner-provided design specifications. The trade-off between cost and safety, if any exists, is the key issue in this debate.

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Theoretical Foundations of Leadership in TQM

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There is a raised awareness of the need for improvement within our organizations. This awareness has been the catalyst for many leaders to implement the Total Quality Management philosophy as a way of life in many organizations across the U.S and abroad. This paper discusses the leadership necessary to successfully make the transformation from the "way we've been doing things for the past thirty years "to the "total quality way." The discussion looks at many variables involved in leading this transformation and supports the Transformational Leadership Theory as the best leadership for implementing improvement strategy changes such as TQM.

Key Words: Total Quality Management, Leadership, Managing Change

Introduction

Throughout history leaders have emerged to deal with a gambit of needs. A few individuals that come to mind include Napoleon, Churchill, Martin Luther King, Joan of Arc, and perhaps, W. Edwards Deming. Each of these people, independent of their race, sex, creed, religion, or nationality, had a desire to make changes within their (systems) society. Even-though these leaders achieved differing levels of success, each of them had a clear vision, along with a well established, long-range plan for obtaining that vision. This author defines a vision as the desired future position of a system or organization some twenty-plus years in the future. In other words, a vision is where a leader wants to take his followers in terms of philosophy, goals, strategies, and the methodologies to obtain, maintain, and continuously improve this new system of values and management.

Leaders recognize that changes cannot be "trendy" nor can they be "quick fixes". Lasting and effective changes require extensive planning, effective leadership, and a constancy of purpose to see it through implementation. Two models currently being utilized for implementing change include Sink's (1992) Performance Improvement Planning Process (PIPP), a vital part of his Performance Management Process (PMP), and Deming/Shewhart's Plan-Do-Study-Act Model (PDSA).

Successful leaders throughout history have always had a vision for change from a current or existing state to a new enhanced state. These envisioned situations were developed with not only their followers in mind, but along with the leader's well thought out plan for obtaining, maintaining, and improving the desired change. The same holds true for those managers wishing to implement changes or adopt new styles of management or organizational systems such as Total Quality Management (TQM), the focus of this paper. This paper will identify the relative leadership theories required to support the implementation of TQM by first discussing the foundations of leadership. Second, this paper will attempt to determine what TQM actually entails by developing an operational definition. This will be followed by a discussion of the implementation process of TQM. The fourth section of this paper will develop a correlation between the theories of leadership, TQM, and implementation procedures in order to offer thoughts on which leadership theories best support the Total Quality Management transformation. The paper will close by offering a summary and conclusions.

Foundations of Leadership

Prior to looking at the various theories of leading changes, one must define leadership. Leadership was broadly defined by Yukl (1989) as "influencing task objectives and strategies, influencing commitment and compliance in task behavior to achieve these objectives, influencing the culture of an organization." In simpler terms, leaders influence the actions and behaviors of their followers to obtain a shared vision or aim. According to Deming (1992), leadership must come from top-management and leaders must possess profound knowledge. By profound knowledge, Deming meant that one must have knowledge of systems, knowledge of variations (statistical thinking), knowledge of theory, and knowledge of psychology.

Leadership is quite different from managing. Leaders grow from mastering their own conflict that arises during their developing years using internal strength to survive. On the other hand, managers tend to perceive issues as positive progressions of events that must be planned, organized, scheduled, and controlled.

Leadership is based upon a common thread between those who lead and those who follow into the same moral and emotional commitments. A crucial element of leadership is the willingness of the leader to use their power in the best interest of all those involved within their organization (Zaleznik, 1989). Leadership should not be confused with heroism. Heroics come about as achieving outstanding levels of performance during dramatic situations, while leadership is the ability to foster superior performances time and time again. Leaders do so by constantly contributing to the thinking necessary to move organizations beyond problems to opportunities. In order to create the proper thinking perspective leaders must aggressively investigate and act on the current market to create opportunities. Now that we have discussed the principles of leader and leadership, let us identify some of the various leadership theories that have been linked to implementing change so that we can develop a higher level of understanding.

The Transformational Leadership Theory (Tichy and Devanna, 1986) contains four suggested personal characteristics of a leader: (a.) dominance, (b.) self-confidence, (c.) need for influence, and (d.) conviction of moral righteousness. These leaders are expected to deal with the paradox of predicting the unknown and sometimes unknowable.

These transformational leaders motivate their followers (Bass, 1985) by: (a.) raising their followers consciousness about the importance of outcomes, (b.) showing the value of group or organizational focus over that of individual focus, (c.) raising the workers' needs so that they value challenges, responsibility, and growth. The Behavioral Theory of Leadership, a paradigm shift away from Trait Theory, includes two dimensions of leadership. One of these dimensions is that of the employee-oriented leader, which focuses on involving and supporting the individual worker. Another application of the Behavioral Theory is Blake and Mouton's Managerial Grid (1978) that reflects leadership styles on the interaction of a concern for the production (getting the job done) and a concern for people. Blake and Mouton believe that this interaction determines the success of management. The higher the concerns for both production and people the more whole-istically focused the leader, resulting in more successes (See Figure 1).

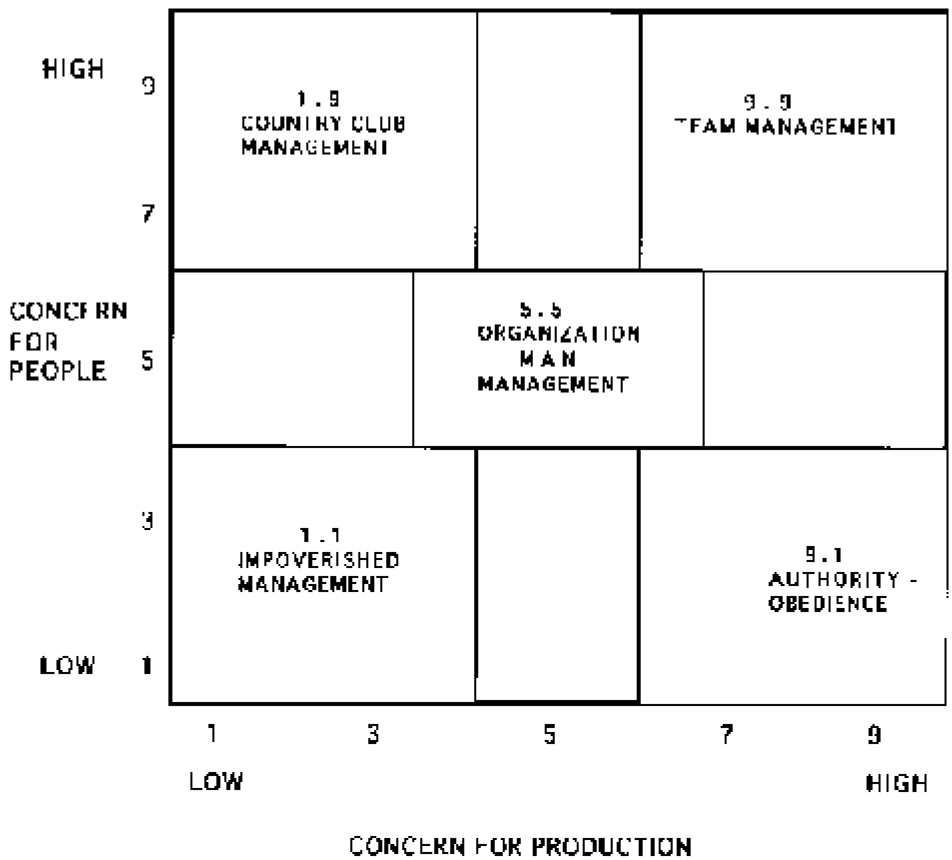

Figure 1. Blake and Mouton’s Managerial Grid (1978)

Referring to the managerial grid, if someone has a high concern for the employees and a low concern for production, that person would find their management style in the corresponding segment of 1-9, a.k.a "country club management". This would be contrasted by the manager who has a high concern for production and a low concern for the employees, which results in what is characterized as an authoritarian type of manager in segment 9 - 1. Some of the principles incorporated in this theory include employee involvement, open communications, shared decision making and problem solving, teamwork, shared goals, and interdependence of teams or individuals, i.e... systems.

Another change leadership theory is that of Hersey and Blanchard's (1982) Situational Leadership Theory. This theory is founded on the interrelationships among (1) "amount of direction a leader gives (task behavior), (2) the amount of socio-emotional support (relationship behavior) a leader provides and (3) the maturity level of the followers on a specific task or objective." Task behavior is the level to which a leader provides explanations (one-way communications) to each follower in terms of what, how, when and where tasks must be accomplished. Relationship behavior is the level to which a leader develops two-way communications for the accomplishment of the objectives by effectively establishing personal relations with their followers. Hersey and Blanchard define maturity as "the capacity to set high but attainable goals, willingness and ability to take responsibility, and education and/or experience of an individual or a group." The Situational Theory asserts that there is not a single leadership style for all occasions, but rather a style that is required for each type of situation. One can determine the desired leadership style by utilizing the Situational Leadership Model (See Figure 2).

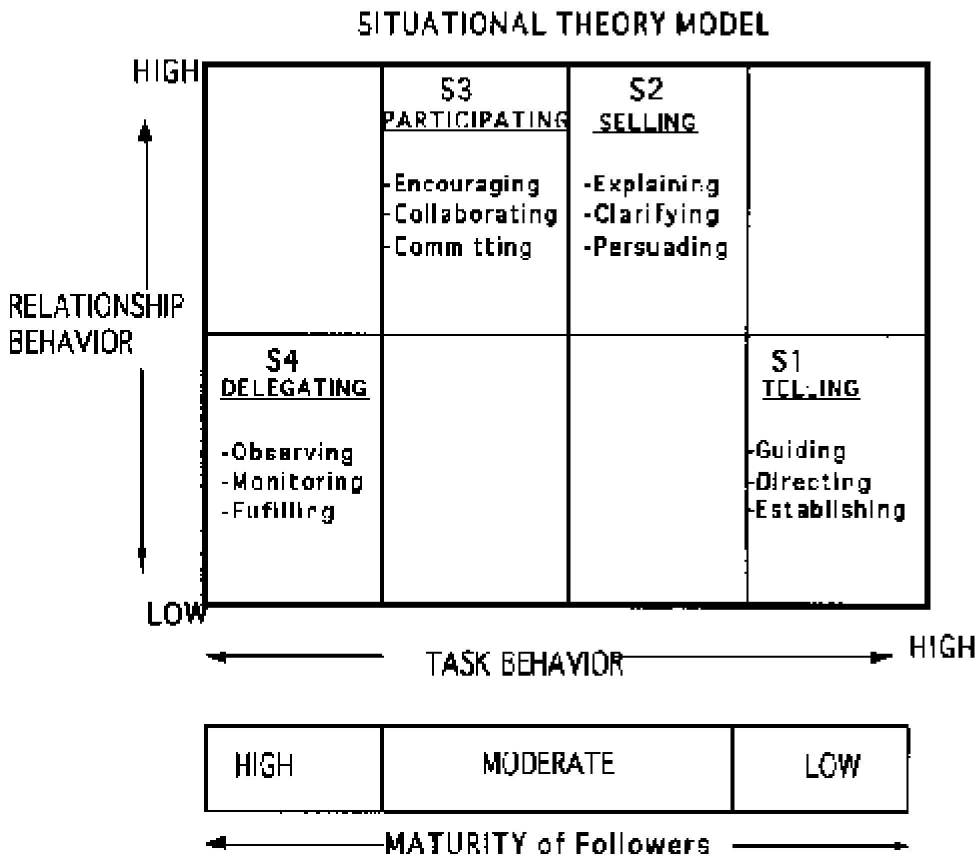

Figure 2. Situational Leadership Model by Hersey and Blancharl (1982)

Once the maturity level of the followers is established and the task/relationship behaviors of the leader are identified, the quadrant of the appropriate leadership style can be selected. The final theory that we will discuss is the New Leadership Paradigm (Sims, 1991). This paradigm describes that of the SuperLeader or leading others to lead themselves.

These SuperLeaders develop SuperFollowers who are skilled self-leaders utilizing some of these fundamentals:

- leader established vision

- leader defines goals for self and followers
- reinforces good performance
- uses constructive contingent reprimand
- manages and facilitates change
- enhances followers' sense of self-efficacy
- leaders use models to teach behavior
- promote self-management
- treat mistakes as learning opportunities
- encourage self-set goals

The presented leadership theories is in no way exhaustive, but offers a fair diversity on which we can develop our thoughts. More specifically, we can now look at TQM and its implementation process while keeping these theories in mind. In doing so, we should be able to successfully identify which theories (or portions thereof) can support the TQM transformation process.

What Is Total Quality Management?

According to Sink (1992), "Total Quality Management (TQM) is the management—planning, organizing, leading, controlling, innovating, and so forth— of performance at five key checkpoints in your organization." (See Figure 3).

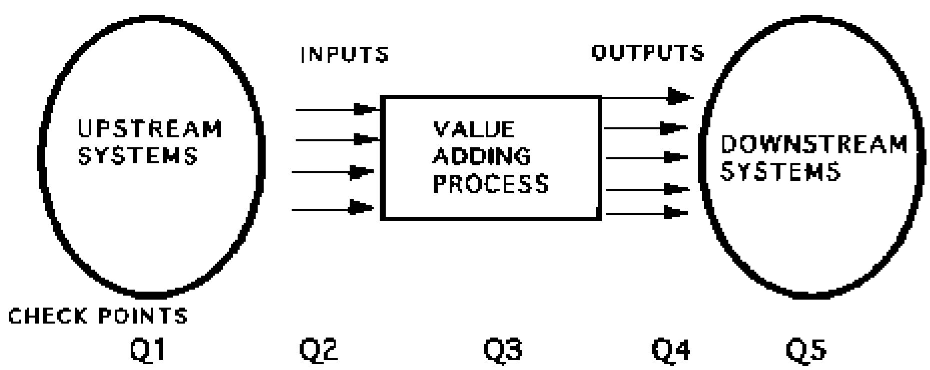

Figure 3. Sink's Five Checkpoints to Total Quality

The five key quality checkpoints he is referring to are:

Q1: Upstream Systems - those from who you receive your inputs.
Q2: Inputs - those used for producing your goods or services.
Q3: Value Adding Processes - converting inputs to outputs.
Q4: Outputs - that which your organization produces.
Q5: Downstream Systems - those who receive your product or services.

TQM is not a process or procedure, but rather a philosophy. Even though Deming never used the "TQM" term in one of his four-day seminars (Oct. 27-30, 1992 - Charlotte, NC), one could sense

Deming's underlying goals on quality. He continually referred to the fact that customers are unaware of what to expect from providers in terms of quality, but "they (customers) are rapid learners" in terms of what to expect. This concept can be applied to both internal and external customers. During this seminar a video was shown entitled "Made in Japan Wholistically", featuring Dr. Yoshida, one of Deming's students. Dr. Yoshida made a point that the major difference between American and Japanese leadership styles is that while the Americans focus on "acceptability" the Japanese focus on the most desirability" of the goods or services. This applies directly to quality, while Americans are used to "acceptable" standards, the Japanese are accustomed to "desirable" ones. It became apparent that Deming and Yoshida shared the belief that by reducing performance variations one can improve quality. More specifically, Deming eludes to quality in eight of his fourteen points and reiterated several times that "quality must be everyone's job" and that "quality does not come from inspection, but from improving the process," again the reduction in performance variation. Since quality is in the "eyes of the beholder", TQM can be different things to different people, but our operational definition for this paper will be the philosophy and supporting strategy for continually improving the performance of all areas or levels of the organization or system. Given these views on TQM, we will now look at some of the implementation considerations that may be addressed in the transformation to TQM.

Transformation to Total Quality

As previously mentioned, in order for an organization to implement long-lasting change it must have a plan or method. According to Peter Scholtes, "TQM implementation takes forever, its never ending." Scholtes also suggests that leaders should not have to sell TQM to their followers, the followers should want to steal it (Scholtes, 1992). The foundations of Total Quality Management rest on the individual workers and their participation, leaders must create the proper environment for their followers to contribute. With this in mind, a brief look at the timing of participative efforts is warranted here.

Rosabeth Kanter (1983) identified several conditions as "appropriate" for participation / involvement; some of which include:

1. A need exists to gain from new sources of expertise, experience, and background.
2. When a collaboration of efforts will multiply the individuals performance through providing assistance, backup, or stimulation.
3. Participation allows all of those who feel that they can contribute to a subject the opportunity to get involved.
4. Participation is ideal for building a consensus on a controversial issue, both in terms of problem-solving and decision-making.
5. Participation lends itself to addressing conflicting interests, approaches, or desired outcomes.
6. Participation is beneficial when a need exists to develop, educate, and train people. Sharing ideas to create new skills or better ways of doing things.

Kanter's list does not include some items that others recognize as being crucial to the appropriateness of participation. First, the proper culture must exist that supports such employee interaction. It has been written that participative management fails, not because of the idea, but due to the lack of a proper design, or even more so, the lack of the proper management culture. This reinforces the point made earlier about the leaders role in developing and maintaining the proper culture to foster employee contribution.

In addition, J. Richard Hackman (1986) has come up with a much broader list of conditions that support participation and should exist, or be developed, in order for participation to be appropriate. According to Hackman's research, the following five conditions support effective self-management, the highest form of participation programs:

1. The overall direction of the work is clear and engaging.
2. The structure of the performing unit fosters competent performance, through the design of the task, the composition of the unit, and sent expectations of regarding the management of performance processes.
3. The organizational context supports competent work, through the reward, education, and information systems.
4. Expert coaching and consultation are available and are provided at appropriate times.
5. Material resources are adequate and available.

Actively implementing TQM Philosophies and participative efforts also be expected to have more relevance in environments that are undergoing both technical and social change. Technical and social changes have been much the case for the construction industry. By tapping those people closest to the technological or social situation, organizations can more effectively move to improve performance.

Two methods introduced earlier in this paper were Sink's (1992) Performance Improvement Planning Process (PIPP) shown in Figure 4, and the Deming/Shewhart Plan-Do-Study-Act Model (PDSA)

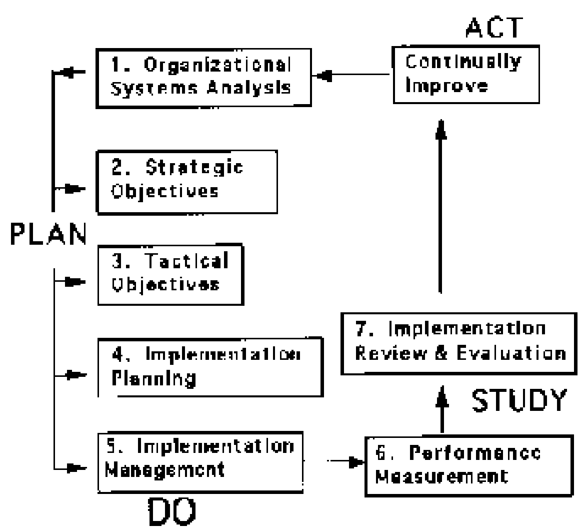

Figure 4. Performance Improvement Planning Process with PDSA Overlay

Since the focus of this paper is leadership theories, we will not spend a lot of time discussing these models, but will offer some major points that must be considered if an organization is to be successful in the TQM implementation process. According to Gambrell and Stevens (1992), "A manager must learn to understand the nature of the change and take a proactive role in communication before, during, and after the change. The more the human side of change is understood, the better positioned one will be to complete and provide a positive work environment." Proper leadership during all stages of change is expected by the employees and requires vital communicating of the reasons behind such a change. This helps ensure that the employees can identify where they fit into the transformed organization and which of their skills are transferable. If one wanted a shopping list of issues that must be addressed when considering a transformation, it would include, but is not limited to, the following items:

- Must have Top Management level commitment and support for the effort to change.
- Must have a vision, constancy of purpose, and a planned strategy of implementation.
- Must obtain a critical mass of profound knowledge -masters'.
- Leaders must "walk the talk" and be exemplars.
- Make the efforts a living plan of continuous improvement.
- Patience and perseverance are key behaviors required.
- Must develop the infrastructure to support the change.
- Identify and eliminate the roadblocks to success.
- Go beyond the quick fix mentality by addressing lessons learned.
- The philosophy is a quality vision.
- The goal is total customer satisfaction.
- The strategy is to focus on the process.
- Must focus on the long term and eliminate short-term mentality.

Perhaps, one of the simplest ways to look at the implementation of total quality management comes from Jagdish Parikh (1991) a self-management author. Parikh developed what is known as the Dissonance Factor Theory. According to the model shown in Figure 5, matching what one wants to do with what one has to do and are capable of doing will inevitably bring about satisfaction and joy for the person. Using this theory, an effective leader implementing TQM must:

- ask their followers what it is they want to do,
- help their followers become capable of doing those things they want to do through effective training programs, and
- then require that the follower does it regularly. Thereby creating a situation for the follower that maximizes their potential for joy.

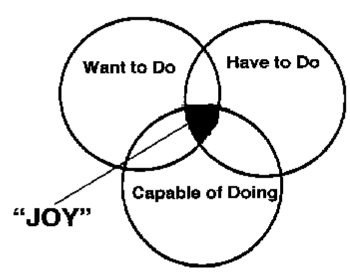

Figure 5. Dissonance Factor Theory Model

Correlating Theories and Implementation

The leadership theories that have been presented must now be correlated with implementation procedures to provide insight into which theories best support implementing TQM. Each of the Leadership theories discussed in this paper made reference to at least one of the thirteen items listed above. For example, in covering the Transformational Leader Theory proposed by Bass (1985), it is discovered that each of the three motivating basis of its followers fit the TQM mold. These components dealt with "raising" either the consciousness of the workers about their outcomes, their individual growth, or their focus to that of the system and not the individual. Another example is that of the Behavioral Theory as it poses this type of leader to be "employee-oriented" by focusing on involving and supporting the workers. This would be necessary to implement TQM on a lasting basis. Also under the Behavioral Theory it is suggested that the most successful leaders have a high concern for both production and their followers, which is again a needed trait for successful implementation. In looking at the Situational Theory, it appears that the most beneficial leader style would be a combination of the S2- SELLING and S3- PARTICIPATING categories, each of which contains traits that would enhance the TQM implementation process. Some of these traits include encouraging, collaborating, committing, guiding, directing, and establishing. Even the New Leadership Paradigm offers some of the desired leadership qualities necessary for implementing TQM, while also containing some attributes that could prove harmful to the transformation. First, the supporting traits include: leader established vision, manages and facilitates change, promotes self-management, and treats mistakes as learning opportunities. On the other hand, some New Leadership Paradigms that could be harmful to the TQM transformation because they go against the TQM philosophy as a whole are: leader defines goals for the followers, this goes against a shared goal, reinforces good performance, this could be a form of a reward system or ranking, and use of constrictive reprimand, which goes strictly against the belief of driving out fear in a TQM environment.

Perhaps the simplest and most practical TQM implementation leadership style could come from following Parikh's Dissonance Factor Theory. Utilizing this as a basis for leadership and managing the transformation encourages a leader to understand their followers through the proper identification of their desires (what they want to do). Followed by ensuring them that they are capable of doing it by providing the followers with effective training. Finally the leader would close the transformation cycle by requiring their followers to utilize these desired skills in the completion of the change as well as in their daily job responsibilities. By effectively addressing the areas of what followers want to accomplish and making them capable of doing so, then requiring them to do it, you in fact have managed change and quality totally.

Summary and Conclusions

The paper first discussed how the leaders throughout history dealt with the challenges that they faced. It was then pointed out that there are no "quick fixes" and that successful leaders had an extensive plan. Next the paper looked at some of the leadership theories and their underlining principles. This was followed by an attempt to define Total Quality Management and its implementation procedures. In the final section of the paper we were able to draw some limited connections from the theories to the implementation process, bringing us to the point where we must make a conclusion. Each of the theories investigated have some of the desirable traits required for leading a change or transformation. It may not be conclusive as to whether one style of leadership is most suited for implementing TQM, one that appears to be very close would have to be that of the Transformational Theory by Bass (1985). This style included three very important issues concerning "raising" the consciousness of the workers, their sense of outcomes, and focus on the organization and not the individuals. However, after facilitating and observing the implementation of Total Quality Management into a number of organizations, this author must support the use of the Dissonance Factor Theory as the ideal basis for leading the transformation to TQM. This theory provides a very clear method, while focusing on three key employee related components, the employee's desires, training, and utilizing their skills in fulfilling their roles and responsibilities.

This is not to suggest that the other leadership styles would fail, but that they may lend themselves to a different culture better than that of the TQM environment. Nonetheless, management must give the transformation the utmost commitment or it shall fail, no matter which leadership style is used. Remember, sometimes the simplest ideas foster the greatest performances.

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ISO 9000 in Construction

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The number of ISO 9000 registered firms in the US and Europe is growing rapidly. Reasons for registration are retention of market share, customer pressure, trade in the European Community and desire to establish a functional quality management system. Construction contractors in Europe are seeking and obtaining registration. The trend toward registration may soon affect US construction contractors. Registration will require significant commitment of time and money for domestic contractors.

Key Words: ISO 9000, Quality Management System, Construction, European Community

Introduction

Markets and Attitudes Are Changing

These days, "quality" has everyone's attention in the construction industry. One quality management system receiving much attention lately is ISO 9000. Construction firms account for only a small fraction of ISO 9000 companies worldwide. However, the standards incorporate basic quality management principles that are similar for most industries (in fact, the standards are remarkably generic). This paper puts ISO 9000 in perspective for the domestic construction industry. Some new information is provided on European construction companies' adoption of ISO 9000. A history of the standards and how they were developed is included, as well as information on ISO 9000 companies in construction and other industries. The domestic market is increasingly affected by foreign competition. In 1980 only two of the 100 largest construction firms in the US were fully or partially foreign owned. In 1993, 22 of the largest 100 had at least partial foreign ownership (Lowder 1994). Trends toward registration in other industries could soon compel some US construction companies to seek registration. Insituform Technologies, Inc. in Memphis, TN, is currently seeking ISO 9001 registration for the manufacture of a popular licensed product for sewer lining and rehabilitation. The firm will seek registration for the entire manufacturing, research and development and construction operations in the US, Canada and Europe. In addition, Insituform is advising domestic utility contractors ISO 9000 registration will be required for installers of the firm's licensed product. Insituform's reasons for pursuing registration are access to European markets, anticipated requirements of the domestic market and establishment of a base for corporate commitment to quality. The company views ISO 9000 as a mechanism for long-term improvement through a continuous process of problem identification and corrective action (Matheson 1994). Domestic construction contractors are not likely to pursue registration without economic pressure. A prediction has been made that registration may soon be demanded by purchasers in the domestic construction industry. Many large domestic industrial manufacturers have received registration and may begin requiring registration for contractors bidding on private construction projects (Lew 1994). The United States Department of Defense (DOD) has approved use of ISO 9000 standards in lieu of MIL-Q-9858A whenever practical ("Undersecretary" 1994).

Background of ISO 9000

International Organization for Standardization (ISO)

ISO was founded in 1946 to promote voluntary, manufacturing, trade and communication standards. The organization is based in Geneva, Switzerland, and includes 92 member countries and approximately 180 standard-drafting technical committees. The name "ISO" is not a jumbled acronym for The International Organization for Standardization. ISO actually refers to the Greek word, isos, meaning equal. The preferred pronunciation is one word, "ISO," not spelled out as "I-S-O". In any case, ISO has become the short name for the organization (Marquardt 1994). The US member representative for ISO is the American National Standards Institute (ANSI). The American Society for Quality Control (ASQC) formed the Technical Advisory Group (TAG) to technical committee 176 (TC 176) for ANSI. TC 176 drafted the ISO 9000 standards ("Registrar" 1992). The US TAG to TC 176 currently includes 141 participating members, 23 reviewing members and 67 observers (Arter 1994). The domestic version of the ISO 9000 standards is sometimes referred to as ANSI/ASQC Q90 ("Registrar" 1992).

ISO 9000 Standards

The ISO 9000 series of quality management and assurance standards were issued and approved in 1987 by 35 countries. TC 176 spent seven years developing the standards ("Registrar" 1992). By 1994, 80 countries had adopted the ISO 9000 standards as a national standard ("ISO 9000 Registered" 1994). The ISO 9000 standards evolved from government and non-government quality systems, chiefly MIL-Q-9858A and BS 5750 as shown in Table 1 ("More" 1992). Three major elements of the standard are the quality system, quality policy and quality management. Quality management includes determination and implementation of the quality policy. The quality system includes the procedures, processes, responsibilities and organization for carrying out quality management. Quality policy includes the overall goals of the organization with regard to quality as expressed by top management ("ISO Quality" 1994). The standards consist of five documents. Organizations may seek registration under ISO 9001, ISO 9002 or ISO 9003 as described in Table 2. The actual ISO 9000 document defines key quality system elements and serves as a guideline for choosing the standard for registration. ISO 9004 provides general guidelines for internal quality management. ISO 9001, ISO 9002 and ISO 9003 have overlapping requirements. The major sections of ISO 9001, ISO 9002 and ISO 9003 are shown in Table 3 (ANSI/ASQC Q90-1987 1987). ISO 9001, ISO 9002 and ISO 9003 cover a progressively smaller scope as shown in Figure 1. However, registration under ISO 9001 does not imply registration to ISO 9002 or ISO 9003. Likewise, ISO 9002 registration does not imply ISO 9003 registration. ISO 9001 is the broadest and most inclusive standard--providing "cradle to grave" coverage--encompassing the entire life cycle of a product from design to after-sales servicing. The major difference between ISO 9001 and ISO 9002 is the lack of design control. ISO 9002 covers quality in production and installation. ISO 9003 registration is appropriate when quality requirements are monitored only for final inspection ("Demystifying" 1993). In 1994, the ASQC published revised standards ANSI/ASQC 9000-1, ANSI/ASQC 9001, ANSI/ASQC 9002, ANSI/ASQC 9003 and ANSI/ASQC 9004-1 revisions. The revised standards have the same basic structure as the 1987 standards. Most revisions to ISO 9001, ISO 9002 and ISO 9003 standards were for clarification purposes. The clause numbering system was modified to be consistent in each standard. An important change was the addition of servicing to ISO 9002 (Table 3) (Durand et al. 1994).

Table 1

Development of ISO 9000

Year	Event
1959	US Department of Defense (DOD) established MIL-Q-9858 quality management program
1963	DOD revised MIL-Q-9858 to MIL-Q-9858A[a]
1968	North Atlantic Treaty Organization (NATO) adopted quality program requirement divisions of MIL-Q-9858A to produce Allied Quality Assurance Publication 1 (AQAP-1)
1970	UK Ministry of Defense adopted provisions of ADAP-1 as Management Program Defense Standard (DEF/STAN 05-8)
1979	British Standards Institute (BSI) developed Commercial Quality Standard BS 5750
1980	ISO TC 176 began work on ISO 9000
1987	International Organization for Standardization issued ISO 9000[b]
1987	American Society for Quality Control (ASQC) adopted ISO 9000 standards as ANSI/ASQC Q90 Standards
1987	BSI revised BS 5750 to be identical to ISO 9000 standards
1992	NATO began revising Quality System Standards to include ISO 9000
1994	US Department of Commerce (DOC) and DOD adopted ISO 9000 standards

[a]MIL-Q-9858A is still in use and has not been revised since 1963.
[b]The standards issued were similar to BS 5750.

Table 2

Description of ISO 9000 Standards

ISO Standard	Scope
ISO 9000: Quality Management and Quality Assurance Standards-Guidelines for Acceptance and Use	Provides a guide to selection of the ISO 9000 series appropriate for a particular business. Registration is not actually issued under "ISO 9000."
ISO 9001: Quality Systems-Model for Quality Assurance in Design/Development, Production, Installation and Servicing	Registration under ISO 9001 is appropriate when the organization desires to demonstrate capability in design and supply of products.
ISO 9002: Quality Systems-Model for Quality Assurance in Production and Installation	Registration under ISO 9002 includes process control for production and installation of products, but not design*.
ISO 9003: Quality Systems-Model for Quality Assurance in Final Inspection and Testing	Registration under ISO 9003 demonstrates capability to detect and control non-conforming product at final inspection and testing only.
ISO 9004: Quality Management and Quality Systems Elements-Guidelines	Provides a guide for the development and management of a quality management system. Registration is not issued under ISO 9004.

*The 1994 revision includes service.

Table 3

ISO 9000 Quality System Elements

Elements	9001	9002	9003
Management Responsibility	XXX[a]	XX[b]	X[c]
Quality System Principles	XXX	XXX	XX
Internal Audits	XXX	XX	--[d]
Contract Review	XXX	XXX	--
Design Control	XXX	--	--
Purchasing[f]	XXX	XXX	--
Process Control	XXX	XXX	--
Production[f]	XXX	XXX	--
Product Identification & Traceability	XXX	XXX	XX
Inspection & Test Status	XXX	XXX	XX
Inspection & Testing[f]	XXX	XXX	XX
Inspection, Measuring, & Test Equipment[f]	XXX	XXX	XX
Control of Nonconforming Product	XXX	XXX	XX
Corrective Action	XXX	XXX	--
Handling, Storage, Packaging & Delivery	XXX	XXX	XX
After-Sales Servicing	XXX	XXX[e]	--
Document Control[f]	XXX	XXX	XX
Quality Records[f]	XXX	XXX	XX
Training	XXX	XX	X
Statistical Techniques	XXX	XXX	XX
Purchaser Supplied Product	XXX	XXX	--

[a]XXX Full requirement.
[b]XX less required than 9001.
[c]X less required than 9002.
[d]-- Not required.
[e] Added in 1994 revision.
[f] "Hard" elements, according to Stein (Stein, 1994).

Registration

The standards provide a benchmark for compliance. Third-party registration by an accredited registrar means the company has been independently audited against one of the ISO 9000 series standards. The audit includes an evaluation of the company's quality manual. Other areas evaluated in the audit could include estimating, purchasing, engineering, construction (production), shipping, service, installation or any function relevant to the standards. Auditors verify that the company is following the procedures described in the documented quality system. When the registrar is content with any corrective actions taken, the registrar may present a certificate of registration for the company's quality management system to the organization. Follow-up audits are usually required semi-annually. Most registrars require a full reassessment every three years (Lofgren 1991). Figure 2 shows typical steps in the registration process (Lew 1994).

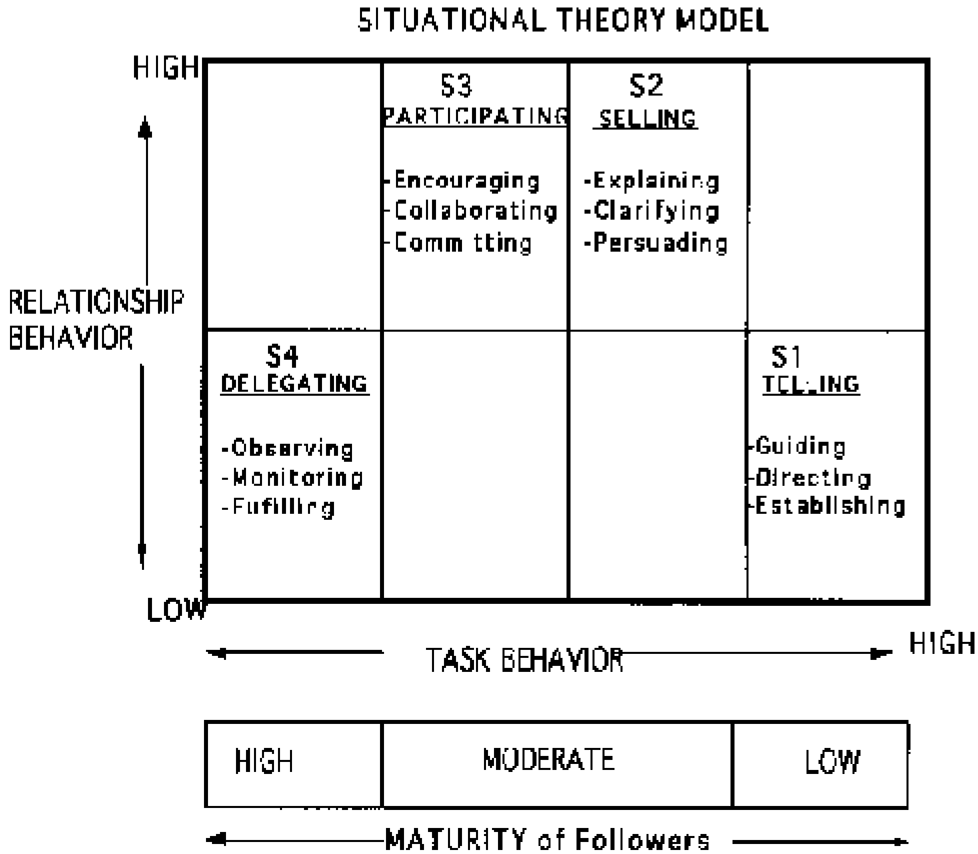

Figure. Situational Leadership Model by Hersey and Blanchard (1982)

The Registrar Accreditation Board (RAB)

Registrars certify or register companies' quality management systems. The RAB was formed in 1989 by the ASQC and is responsible for investigating the competency of registrars. Both groups are headquartered in Milwaukee, WI. The RAB issues accreditation to registrars in conformance with EC and ISO requirements for registrars. The RAB was the third national accreditation body formed world-wide. Selection of a registrar is complicated by refusal of some European companies to accept registration by foreign registrars. International recognition of a company's registration is not possible without mutual recognition of the issuing registrar's accreditation (Stratton 1992). Broad, mutual recognition by accrediting bodies throughout Europe has not occurred. However, the RAB has signed a memorandum of understanding (MOU) with Raad voor de Certificatie (RcV), the Dutch Council for Certification in the Netherlands which should lead to mutual acceptance of registrar accreditation in the US and Europe in the future. By August 1994, 52 registrars, including many foreign registrars, had received RAB accreditation ("ISO 9000 Registered" 1994).

The European Community (EC)

The existence of the large European Community trading block has increased demand for suppliers to obtain registration. Much of the recent interest by US manufacturers in the ISO 9000 standards is due to concern about access to European markets. The Single European Act of 1986 called for elimination of trade barriers between the 12 member states and the formation of a single internal market, known as EC 92. Products traded in the EC are subject to a complex product conformity process. The conformity assessment process created fear of exclusion from the European market. Because of EC 92, the European Community began to develop formal conformity assessment processes for products sold in the EC. All products sold in the EC are classified as regulated or non-regulated products. As much as 50 percent of US exports to the EC are subject to regulation (Spizizen 1992). Non-regulated products may be accepted in the EC by mutual recognition if the product meets a technical standard recognized by any EC member country. Regulated products are defined as having important health, safety or environmental impacts. Sale of regulated products is directly controlled by EC legislation in the form of "directives" that are binding on EC members. Directives are the result of the complex EC legislative process. Directives set standards for products by referencing appropriate technical standards for product design, product testing and frequently, the manufacturer's quality management system. Since the EC has adopted the ISO 9000 series as the model for quality management systems, in effect, "compliance" to an appropriate ISO 9000 quality management system has become a requirement for sale of many regulated products in the EC (Marquardt 1994). Regulated products account for approximately 15 percent of all products made and sold in the EC and roughly one-half of the dollar volume exported from the US to the EC (Spizizen 1992).

Demographics of Registered Companies

Any type of company can seek registration to an appropriate ISO 9000 standard. Because of the organizational structure of ISO, no "master list" of all registered sites in the world is maintained. Therefore, estimating the total number of ISO 9000 registered companies is difficult. An estimated 45,000 companies are currently registered in Europe. Accurate estimates for Asia, Africa and South America are not available (Brown 1994). More accurate figures are available for North America. In January 1993 there were approximately 700 registered firms in the US. By August 1994 at least 4,185 companies were registered in the US; Canada had at least 875 registered sites and Mexico had 75 to 100 sites (Campbell 1994).

Registered Construction Firms in Europe

A 1993 survey of the European Construction Industry Federation (ECIF) showed that the UK had 95 to 100 registered construction companies in 1993. An estimated 10 to 20 German construction companies held registration in 1993 ("Analysis" 1993). A single German registrar had at least 15 construction companies with registered sites in Germany, four in South Korea, one in Chile and one in India by June 1994 (TÜV 1994). The Czech Republic had the next most registered firms with 79. Switzerland had no registered construction companies at the time of the survey, but reported that 20 firms were expected to receive registration. Belgium, Spain and Portugal reported no registered construction companies. The number of registered construction companies and registrars reported for ECIF countries is shown in Table 4. ECIF members stated the main reasons for construction companies to obtain ISO registration were demands of clients and internal economic reasons. Components of the ISO 9000 standards most difficult to comply with were internal quality audits, contract reviews, process control, procedure writing, documentation, assessment of subcontractors, control of non-conforming products, corrective action and interpretation of (all) standards. Guidelines for ISO 9000 implementation in construction companies are available in 10 of the countries represented. The survey reported that in eight countries the bodies responsible for registering companies held legal status (Table 4). The ECIF members responding for six countries were in favor of requiring construction companies to be registered as part of a qualification system. The UK strongly opposed mandatory registration. A majority of the ECIF members were interested in participating in the development of a European Guide to assist construction companies in obtaining registration ("Analysis" 1993). Concerns over requirements for registration in the German construction industry has led to sponsored research at Ruhr University at Bochum by a working team specializing in tunneling and pipeline maintenance. Many construction firms not holding registration nonetheless have procedures in place that are consistent with ISO 9000 requirements. Many European construction professionals are engineers by training and are used to meeting technical standards and have less expertise in the organizational requirements of ISO 9000. ISO 9000 is described as an optimization process for the organization of a company and the technical processes of the company. Elements of the ISO 9000 standard can be described as "hard" elements referring directly to production and "soft" elements that include elements of management such as management responsibility and quality system principles (Table 3). Many elements of management are independent of the type of work the company performs. Companies should find more help available in adopting the "soft" elements because many registered firms, while not construction firms, have similar management functions. Construction companies have many different production techniques. Companies face difficulty in determining the depth and scope required in documenting procedures. "Hard" elements should be more difficult to adopt because the elements are more likely to be company or industry specific. (Stein 1994).

An UK listing of registered companies included more than 500 listings for construction companies in 1994. Many companies had more than one registered site (DTI 1994). ISO 9000 companies in the UK are found in nearly all sectors of the commercial and industrial construction industry as well as engineering. The UK version of ISO 9000 is known as British Standard 5750 (BS 5750). Important reasons UK construction companies sought registration included customer demands, marketing advantages and the opportunity to begin building a corporate quality culture (Pateman 1994). The Construction Industry Training Board in the UK has produced a guide for implementing a quality management system in a construction company and a guide to ISO 9002 registration for construction companies ("Guide" 1991).

The UK construction firm Crispin & Borst achieved registration to BS 5750-2 (ISO 9002) in June of 1993. The effort took more than two years. The firm hired consultants to assist in documenting the company's existing procedures. A six-member inter-departmental management team reviewed the work to produce a set of procedures that could be carried out without significant extra work. A consultant assisted in comparing the written procedures to BS 5750 and addressing items needed to comply. The system was put into operation throughout the company for about six months prior to a successful registrar's audit (Sims 1993).

Table 4

ISO 9000 Registered Construction Enterprises and Registrars in the European Construction Industry Federation (ECIF)

Country	Construction Companies	Registrars
Austria	not reported	not reported
Belgium[a]	0	7
Switzerland[b]	0	2
Czech Republic[a]	79	2
Germany	10 to 20	5 to 15
Denmark[a,b]	10 to 15	2
Spain[a]	0	1
France[a]	2 to 3	3
United Kingdom	95 to 100	5 or 6
Greece	not reported	not reported
Hungary	not reported	not reported
Italy[b]	5	0
Ireland[a,b]	25	1
Iceland	not reported	not reported
Luxembourg	1	0
Norway	not reported	not reported
Holland	10	3
Portugal[a]	0	0
Sweden[b]	1[c]	3
Findland[a,b]	1 or 2	3 or 4

[a]Certifying bodies have legal status.
[b]ECIF member group favors establishing a notional qualification system requiring ISO 9000 certification of companies.
[c]Specialized enterprise

US Construction Companies

Six firms with a Standard Industry Code (SIC) in a construction division have US sites registered to a specific ISO 9000 standard as shown in Table 5. Several are well-known construction/engineering firms. However, none of the six firms' registration scope is directed at the commercial, non-industrial construction industry. One firm with a registered site is a wholly-owned subsidiary of the UK firm Trafalgar House which holds numerous registrations in the UK. Although classified under SIC 1500, Building Construction, the firm's scope is chiefly design and construction in the process plants. Two firms hold ISO 9001 registrations under SIC 1600, Heavy Construction. The registration scopes include chemical and petrochemical facilities and the oil and gas industry. Three firms hold ISO registrations under SIC 1700, Construction Special Trade Contractors. The firms include a construction/engineering field office serving a Monsanto Chemical plant in Gonzales, FL, a designer and installer of specialized communications and medical systems and a manufacturer of steel roofing products ("Registered" 1994).

Table 5

Companies with ISO Registered Sites in the US with Construction SIC Codes

COMPANY/SCOPE	REGISTRATION
SIC 1500 Building Construction—General Contractors and Operative Builders	
John Brown, Division of Trafalgar House, Inc.	
Design, procurement, project management, validation documentation, management of site construction and installation of process plant and facilities projects	9001
SIC 1600 Heavy Construction Other Than Building Construction – Contractors	
Fluor Daniel, Inc. Engineering, procurement, project management, construction and maintenance services	9001
The M.W. Kellogg Company	
Project management, engineering, procurement, construction and field services for the oil, gas, petrochemical and chemical industries	9001
SIC 1700 Construction – Special Trade Contractors	
Fluor Daniel, Inc. Construction and maintenance services	9002
Loral-Western Development Labs	
Design, manufacture, installation and servicing of medical imaging and information systems; distributed simulation and modeling systems; reconnaissance systems; command control, communication and intelligence systems; satellite communication ground terminal training and learning systems and information systems	9001
Roof Tile Manufacturing Company Manufacture of steel roofing tiles and accessories	9002

The Power Division of Black & Veatch is seeking ISO 9001 registration for design, construction management and procurement in Kansas City, MO. The site includes about 1700 employees. Richard White, head of the Power Division believes that ISO 9000 certification will be required for US architectural/engineering or construction/engineering firms desiring to work overseas (Fairweather 1994).

Conclusions

ISO 9000 standards outline a framework for a basic quality management system. The emphasis is on management procedures. Most domestic construction contractors face little pressure it pursue ISO 9000 registration. However, ISO 9000 can serve as a platform to establish a primary quality management system and introduce more advanced quality management techniques. Establishment of quality circles would be helpful to construction contractors seeking registration. The introduction of ISO 9000 in a construction company may be difficult because the management of the company will be open to scrutiny, and criticism is often difficult for management to endure. Changing attitudes and competition in a global market have focused management attention on quality.

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Selecting the Construction Industry as a Career: An Analysis

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The success of the construction industry is highly dependent on the success of its skilled labor force. In recent years there have been several forecasts that have predicted a shortage in the skilled labor forces. This is attributed to several factors, including a decrease in the labor pool, an overall poor image of the construction industry, the work is physically demanding, and the individual's educational system. This paper will analyze reasons that individuals would or would not be interested in a career in the construction industry. The information in this analysis was complied from three separate surveys: junior and senior high school students, students of associated degree programs in construction, and skilled labor forces employed in the construction industry. The main concentration of this study was the survey used on high school students since they will be the main contributors to the future pool of labor required for construction. The questions were designed to interpret the students' perception of the construction industry and whether or not they have an interest in construction as a career. This paper presents the survey data, data analysis and rationale, and also suggests how this information may be used to help promote construction as a career choice.

Key Words: Construction Careers, Construction labor, Construction Workers, Labor Force

Introduction

The basis for surveying high school juniors and seniors is supported by the fact that these individuals will be making decisions about their future career choices within the next two years. Whether they decide to enter the work force, attend trade schools, or receive degrees from four year colleges, their decisions will determine if the predicted shortage will occur. How these decisions are made, and who influences these students, are key factors. The Jobs Rated Almanac reported that "employment as a construction worker ranked 248 out of 250 occupations based on a rating system that measured factors such as physical demands, stress and long-term security. Construction foreman ranked 228, while civil and electrical engineer ranked 16 and 32, respectively." (Korman, 1992) This ranking either stems from or creates a bad image of construction workers and "provides a glimpse at what information the general public, through respected publishers, are provided. Given the uncertainty many youngsters have with regard to what job/career to pursue, it is clear that for most who consult The Jobs Rated Almanac, the choice is not likely to be a construction worker." (Federle, Rowings, & DeVany, 1993)
In addition, ENR reported that "The reputation of the industry is bad even among school children who picture it as a haven for Neanderthals and ne'er-do-wells and not a provider of sophisticated services". (Korman, 1992) Another study found:

> The term "construction worker," embodied as the unskilled manual laborer, has negative connotations for young people. To youngsters, "construction workers" are ditch diggers they see calling obscenities to passerby, loafing on the job. Most commonly associated with dirt, sweat, and a gruff demeanor, the construction worker lacks prestige, class, and respectability (Rosenthal 1990).

Methodology

The High School Survey

The high school survey (Appendix A, first page) was a one-page questionnaire, intended to take 5 to 10 minutes. It was administered by teachers in five different high schools and given to students in homeroom or a class attended by juniors or seniors. The five high schools are identified as follows:

A. Small community high school (Cozad High School, Cozad,NE)
B. Large inner city high school (Lincoln High School, Lincoln, NE)
C. Large inner city high school (Lincoln Northeast High School, Lincoln, NE)
D. Medium outer city high school (Norris High School, Norris, NE)
E. Small community high school (York High School, York, NE)

Five hundred twenty-nine (529) surveys were completed. There was no screening of the students as to enrollment in technology related courses ("shop classes") or to the participants gender, race, GPA, etc. This enabled a diverse consensus of the high school students' perception of the industry.

In designing the high school survey questions, three categories were established:

1. general awareness of the industry,
2. training/pay, and
3. opinion or perception of the industry's image.

Questions 1,2,3,4,8,9, and 10 are general awareness questions of the industry. Of these questions, 1,2,3, and 4 deal with knowing someone in the industry, and having knowledge of a construction company and a construction project. Questions 8,9, and 10 pertain to classes related to construction in their respective school while, questions 5 through 7 address pay and training. Finally, questions 11 through 13 are opinion or perception oriented. Question 12 allowed the students to offer their opinions, and many of them did. (Appendix B - Results) Their enthusiastic answers told exactly what some of them thought about construction. Question 13 stemmed from an article by Cliff Hicks entitled "But we all have to go to college after high school ...don't we?" (Hicks, 1994) He had many valid arguments that high school counselors should not try to steer every high school senior into a four-year college. Hicks wrote the "concept that everyone must go to college", is an attitude that is prevalent today especially among counselors and parents. He states that he "rarely hears counselors talk about trade schools" but Hicks thoroughly believes that "people who are good with their hands should go to a carpentry school or get an apprenticeship." Hicks cautions, "if the high school system isn't changed and isn't altered into a preparation for life instead of a preparation for college, the unemployment rate will keep rising and our work force will continue to decline".

The Associate Degree Program Survey

The basis for surveying students of associate degree programs in construction was that these people made the decision to seek specialized training for the construction industry. How this choice was made, their level of satisfaction with this choice, and their expectation of their future careers are important issues to analyze. When designing the associate degree program survey questions, four categories were established:

1. programs that their school offered,
2. who or what influenced their decision to attend school,
3. pay/job market, and
4. their opinion of the industry's image.

The results of the four associate degree programs were compiled from one hundred fourteen (114) surveys as illustrated in Appendix B, 2nd page.

Questions 1,2,5,6,7,8, and 9 were developed to determine whether or not the schools are offering the type of programs that are high in demand by both the students and the companies who hire them. The type of classes required shows depth and diversity of the programs. The availability of the classes, the qualifications of the teachers, and the quality of the equipment all relate to the quality of the programs. If, through the surveys, it is found that these categories are scoring low, then it is understandable why high school students are not entering these programs at a higher rate. If the surveys show the programs rate average or above average, then the problem lies with the people who influence high school students such as their peers, parents, and counselors. Who or what influenced these students was covered in question 3.

Questions 4, 10, and 11 pertained to pay and job market expectations upon graduation. The answers are indicative of how the student feels about the value of his or her degree. If they expect numerous high paying job offers upon degree completion, they are more likely to complete the program. If the students feel their endeavors will not benefit them in the future, they are more apt to quit school, seek employment, and have their employer train them in the field. Question 12 asks the participants to state their opinion of the construction industry.

The Skilled Labor Survey

The basis for surveying skilled labor (Appendix A, 3rd page) from area construction companies was to compare their answers with that of the high school students and associate degree students. Full-time employees of two general contractors and one concrete specialty subcontractor were surveyed. One hundred nine (109) surveys were completed.

When designing the skilled labor survey questions, three categories were established:

1. questions related to the company they are employed with,
2. training, and
3. their opinion of the industry's image.

Questions 1,2,3,4,5, and 6 related to the employee's company, specifically, benefits, safety, equipment, and employee turnover. These questions were designed to establish the worker's job satisfaction. If these areas rated low, the company possibly has some personnel problems or the employee may have chosen the wrong career. A high rating establishes that the employee is satisfied with his or her career choice, which in turn initiates the question as to why other people are not attracted to this type of career.

Questions 8,9, and 10 dealt with the training received by the worker, both before and after they joined the company. These questions were asked in order to prove that construction workers are not uneducated and lazy, but are well-educated, well-trained, and hard-working individuals instead. Based upon the fact that the highest level of education required in the U.S. is a high school diploma or equivalent, questions were included to show that a majority of the skilled laborers had achieved or surpassed this goal.

Finally, questions 7, 10, and 11 dealt with the workers opinion of the construction industry's image, who or what influenced their career, and what they would change if they could.

The Results

This paper will mainly focus on the results of the high school surveys with some comparison to the associate degree program surveys and the skilled labor surveys. Due to the massive amount of information gathered, the last two surveys mentioned will be further analyzed in future papers. The number of surveys from each high school are as follows (Table 1):

Table 1

Number of surveys

A -	Small community high school	33
B -	Large inner city high school	280
C -	Large inner city high school	42
D -	Medium outer city high school	82
E -	Small community high school	92

Appendix B gives the results of all surveys, divided by school. The discussion below uses the total composite number of surveys listed in Appendix B. The variance in the total response number of 529 is due to the fact that some questions were answered with more than one answer, and some of the questions were not answered at all.

High School Awareness Category

Questions 1 and 2 indicated that nearly 72% of the students knew *someone* or some *company* in the construction industry. Question 3, awareness of a construction *project* in the local area dropped to about 57%. This may indicate that the construction industry needs to make themselves more known to the general public. A local ABC executive director agrees with this assessment as he stated that "a good percentage of young people see the construction industry as one in which people can earn very good livings, he also noted the construction worker is ahead of only the migrant farm worker in terms of jobs they would actually like to have for themselves. Not good. What the industry needs to do is to show-and-tell the general public that this industry is not so bad. That contractors are safety-conscious and that it's not as dangerous as it used to be. That people from all backgrounds can earn a decent wage - and respect" (Midwest Contractor, 1995).

The list made from Question 4 was not surprising. Many students answered "housing projects". This may be due to the fact that many of these high schools had programs that helped with the actual building of homes for the Habitat for Humanity projects. What was surprising was that 223 of the 529 students (42%) did *not* know of a construction project, even though all of the schools except one had a major remodeling or large addition project under construction at the their respective school.

Question 8 dealt with the students' awareness of their schools offerings of construction related classes. Approximately 91% of those who responded knew the school offered such classes. When asked to name a construction related class offered at their respective school, 65% (344) of those who answered (479 students answered) named "Residential Construction". Finally, when asked if they had to take an industrial technology class, only 93 of the 318 responses listed "Residential Construction". This is a significant drop from the number of students aware of the class, and one could conclude that many students would not even take a class in the construction related area.

Training and Pay Category

Question 5 shows that students believe construction workers earn middle class salaries. It is obvious that they believe this profession does not secure salaries above $50,000 a year but they also do not believe construction workers are living just above the poverty line. Many construction workers are paid by the hour, reflecting an inaccurate perception by the high school students as most indicated these workers were paid on salary. Question 7 dealt with training. Almost half of the students (46%) were aware that most construction workers are trained in the field. The majority of the skilled labor surveys reflected this same response (74%). In reviewing questions 5 through 7, the authors became aware that the correct answer for each would have been that it differs according to the different areas of specialization. For example, electricians are one group who obtain their license after a period of apprenticeship. In the local area, electricians can expect to make $26,000 to $34,000 a year, and are paid hourly. A foreman in the area can expect to make $30,000 to $40,000 a year, and are often paid on salary. (AGC, 1994) Out of the 529 surveyed, only about 10 students answered that it depended on the area of specialization. If students knew more about the industry, more students would have recognized this.

Opinion/Perception Category

High school students answered "no" over 100 times more than they answered "yes" when asked if they consider a career in construction (61% no, 39% yes). Their justifications are listed in Appendix B, Question 12. The number one reason was simply that they were "not interested". A close second was the "work conditions", third was that they "did not know enough about it", and fourth was "low pay". Some of the answers did reflect the attitudes of the students as to why they would not chose a career in construction. Answers like "construction is hard labor"," boring", "I'm a girl", "I like 'thinking' jobs", and "I don't want to be dirty all the time", indicate what people of this age group think about the industry. From these answers, it seems the industry has a not so favorable image with these students.

The participants answered question 13 with an almost even split. This proves that almost 50% of the teens believe a four-year college is the next step after high school, because it would not be cool to do anything else. The problem with this way of thinking is that not everyone ready to attend college immediately after high school. The result is wasted time and money, and ultimately a feeling of failure.

Correlations and Analysis

There are many correlations and comparisons that can be made between the surveys. The high school survey can be compared to the associate degree program survey in the area of pay. It also correlates to the skilled labor survey in the areas of training and safety. The associate degree program survey and the skilled labor survey can be compared in the areas of influence and opinion of the industry.

The high school survey had a few questions about pay. Almost half of the high school students (48%) believe construction workers earn $25,000 - $35,000 per year while less than 1/3 of the associate degree program students (30%) believe they will earn this amount upon graduation. A relatively high percent of the high school students (38%) believe a construction worker makes more than $36,000, in contrast to the associate degree program students where, only 3% believed this. The vast majority of associate degree students (67%) believe their salaries to be in the $10,000 -$24,000 range. Whereas 14% of the high school students believe construction workers earn $10,000 - $24,000. The Table 2 below compares these three salary ranges.

Table 2

Salary Ranges

SALARY	High School Students	Associate Degree Students
$10,000-$24,000	14%	67%
$25,000-$35,000	48%	30%
Above $36,000	38%	3%

The associate degree students have a realistic idea of their salaries. The moderate range for the associate degree students' majority selection reflects that the student is aware that starting pays maybe low with hope for future advancement.

Correlations can be made between how high school students believe the skilled labor forces are trained and how the skilled labor forces actually responded to a similar question. The following comparative results illustrate that the actual workers depend on field training versus the more formal training that the high school students perceived.

Table 3

Field Comparative Results

TYPE OF TRAINING	High School Students	Skilled Labor
4 year bachelor degree	6%	---
2 year associate degree	23%	6%
License after apprenticeship	25%	---
Trained in the Field	46%	74%
Other	---	20%

The above table reflects that the questions were asked in different formats. Question 9, was used to tabulate the skilled labor force answers listed above by including answers a, b, d, and e for "Trained in the Field". The high school students do recognize that a large amount of training is hands-on experience. For the sample of workers used, the vast majority had field training with some additional trade association and/or company training. The low amount of workers having a formal training (associate degree), is positively reflected in their answer to Question 11, which shows their higher desire for more schooling.

The only time job safety was discussed by the high school students was when answering Question 12. Three students believe they could get hurt easily on the job. This is a relatively low percentage of students; thus the vast majority are not aware of any safety problems. This is surprising since the media usually highlights major construction accidents and there is rarely any *good* news portrayed about the construction industry. On the positive side, 95% of the skilled labors surveyed rated safety regulations average to excellent.

When analyzing the associate degree students and skilled labors selection of construction as a career choice, many of the same reasons are cited. Self/family/friends was the top reason given in both surveys, with 60% of the community college students and 20% of the skilled laborers supplying this answer. The second most common response for both was that they enjoy building and working with their hands. In addition, other common responses were "liked working outside"," became interested through past experience", and "needed money". These answers are interesting when they are compared with the high school students answers because *work conditions* was rated second and *low pay* was rated fourth on the high school students' list of why they would not consider a career in construction.

When asked their opinion of the construction industry's image, the people about to enter the workforce had a higher opinion than those already working in the industry. This is no surprise. Individuals usually have higher expectations prior to having actual experience in an area and after working several years, an individual's career choice can become routine. A majority of the associate degree students (40%) believe the industry's image is excellent, while only 13% of the skilled labor force agree. That is a significant drop. The numbers drop again when rating the image as better than average. The following table reflects the view of the image of construction industry in the eyes of the associate degree students compared with the skilled labor force.

Table 4

View of the Image of Construction Industry

IMAGE PERCEPTION	Associated Degree Students	Skilled Labor
Excellent	40%	13%
Better than Average	38%	22%
Average	21%	41%
Below Average	1%	18%
Minimal	0%	6%

The above table was tabulated using Question 11 in the associated degree program survey and Question 7 in the skilled labor survey. As you can see, the majority of the associate degree students rate the image excellent in contrast to the skilled labor majority rating of average.

Conclusion

In the high school response to why they would not choose the construction industry, the highest response was "not interested". The question should then be asked: Why aren't they interested? Is it because of the pay, the image, or the work conditions. The authors suspect that a poor image is the main problem the industry faces in enticing new workers. Part of the solution is to change this poor image. The president of the American Subcontractor Association recently wrote, "if the industry is going to attract quality workers in the years to come, we need to change our image today. We work in a truly challenging and rewarding field. It's time that we start showing people the positive aspects of our industry instead of allowing the press to focus only on the disasters. The bottom line is fairly simple. If we as an industry want to recruit quality workers, we must improve our tarnished image" (Graff, 1994).

Companies can have an extremely large impact on the public. Leaders in the industry have to "pursue a more aggressive path for recruitment and retention in their industry, including specific programs aimed at attracting minorities and women, co-op programs and summer jobs for technical students, support programs in the civil engineering and construction fields at universities, and public education through the media" (Jones, 1990).

Other image building techniques that companies can implement include placing company signs in prominent places on job sites, making clean trucks and equipment a priority, displaying their logo on their trucks and equipment, insisting that all employees keep their work clothes clean and tidy, and exhibit appropriate behavior. Another way is to enlist the help from the media. Start playing show-and-tell with them. Instead of running newspaper crews off of work sites, call them up and ask if they would like to come view the site. If a time is set-up beforehand, the company is in control rather than the public. Employees can even write brief project descriptions and send them to the local newspapers and to trade magazines.

Advertising on television and radio is another great source. Who better to look to for an example of this but the U.S. Army. There was a time after Vietnam war where the Army was having trouble getting people to enlist because of its new found bad reputation. The Army began showing commercials and even came up with a catchy slogan: "Be all that you can be, in the Army". They pushed the positive rewards they had to offer. Construction companies, and even the industry as a whole, could use this concept of advertising. Participation in community activities and agreeing to outside speaking engagements at conventions, conferences, forums, or civic, philanthropic, and youth clubs are excellent public relations tools as well.

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Appendix A

Circle or fill in the blank for your best answer to the following questions.
1) Do you know someone who works in the construction industry? Yes No
2) Do you know of a construction company in your local area? Yes No
3) Do you know of a construction project in your local area? Yes No
4) If you answered yes in question #3, what is the type of project or name of the project.

For #5-7, circle the letter that corresponds to the best estimate of you answer.
5) What is the average pay a construction worker makes in 1 year?
a) above $50,000
b) $36,500 - $50,000
c) $25,000 - $35,000
d) $10,000 - $24,000
6) A construction worker is paid?
a) on a salary
b) different for each project that is worked on
c) hourly
7) How are construction workers trained?
a) They must graduate with a degree from a four year college that specializes in their field of work.
b) They must graduate with a degree from a two year college that specializes in their field of work.
c) They must get their Skilled Labor license after a period of apprenticeship.
d) They are hired and then trained in the field by the company they work for.
8) Does your school offer any classes related to construction? Yes No
9) If you answered yes to #8, name the class/classes. ____________________________________
10) If you had to take an industrial technology class at your school, what would it be?
____
11) Would you ever consider a career in the construction industry? Yes No
12) If you answered no to #11, explain why (low pay, work conditions, don't know enough about it, etc.)
____
13) If you had a friend who was good at/enjoyed working with his/her hands, would you try to talk them into attending a trade school (carpentry, plumbing, etc. instead of a 4 yr. college)? Yes No

Short Answer
1) What program are you currently enrolled in? ______________________________________
2) What type of classes do you need to take in order to receive a degree from this program?
____
3) Who/What was the main influence on you to enroll in this program?
____
4) What type of pay do you anticipate receiving upon completion of your degree? (Circle the letter closed to your answer)
a) $6.00/hr - $8.00/hr ($12,480/yr - $16,640/yr)
b) $8.50/hr - $10.00/hr ($17,680/yr - $20,800/yr)
c) $10.50/hr - $12.00/hr ($21,840/yr - $24,960/yr)
d) $12.50/hr - $15.00/hr ($26,000/yr - $31,200/yr)
e) more than $17.50/hr (more than $35,500/yr)

Use the following rating system to answer the following questions. Place your answers in the blanks provided.
1 = excellent
2 = better than average
3 = average
4 = below average
5 = minimal
5) Rank you availability to get into classes that interest you and have significant application to your graduation date.
____

6) Rank your program's teachers (i.e. 1 = many teachers with a wide variety of field experience, 5 = few teachers, each having minimal amounts of experience). ________
7) Rank your satisfaction with the equipment your program makes available to you for coursework. ________
8) Do you find the classes offered to you are more technical related (computers, CAD, electronics, etc.) rather than hands-on construction related (carpentry, framing, metal work, etc.)?
____
9) Rank your school's job placement service that is offered to graduating seniors. ________
10) Rank the job market that the students who have graduated with construction related degrees in the past few semesters have encountered. ________
11) Of these new graduates, how has their starting pay compared to past graduates' starting pay? ________
12) Overall, what is your opinion of the construction industry? ________

Using the following rating system to answer questions 1 through 7. Place your response in the space to the right of the question.
1 = excellent
2 = better than average
3 = average
4 = below average
5 = minimal
1) How do you feel your benefits (job security, insurance, vacation and sick leave, retirement, etc.) compare to that of other construction companies? ________
2) How do you feel your benefits compare to that of other careers? ________
3) When you are on a construction site, do you feel that the safety regulations you have to follow are adequate enough to make you feel safe? ________
4) How do you perceive your company's accident record (1 = very low accident rate, 5 = very high)? ________
5) Rank your satisfaction with the equipment your company makes available to you for projects. ________
6) How would you rank the employee turnover rate at your company (1 = very low turnover, 5 = very high)? ________
7) Overall, what is your opinion of the construction industry's image? ________

For questions #8 and 9, select <u>all</u> of the following that apply and place your response(s) in the space to the right of the question.
a) High school industrial technology program
b) Informal training through experience
c) Community College Program
d) Company sponsored programs
e) Association (AGC, ABC, etc.) sponsored programs
f) Other
8) What type of training did you receive before you began working for the company you are currently employed with? ________
9) What type of training did you receive since you began working for the company you are currently employed with? ________

Short Answer
10) How did you become interested in a career in the construction industry?
____
11) If you could change one thing about your career, what would it be?
____
12) What is the highest level of education you have achieved? __________________________

Appendix B

HIGH SCHOOL STUDENTS 529 Surveys

1) Do you know someone who works in the construction industry?

Schools	Yes	No	
A	24	9	
B	190	91	
C	27	15	
D	67	15	
E	76	16	
	384	**146**	530

2) Do you know of a construction company in your local area?

Schools	**Yes**	**No**	
A	29	4	
B	191	88	
C	29	13	
D	49	37	
E	84	9	
	382	151	533

3) Do you know of a construction project in your local area?

School	Yes	No	
A	19	14	
B	153	124	
C	17	25	
D	41	40	
E	71	21	
	301	223	524

4) If you answered yes in question #3, what is the type of project or name of the project.

Housing	102	Gas Station/Truck Stop	3
School Addition	83	Roofing	3
Commercial Building	37	Pouring Concrete	2
Road Construction	20	Airport Runway	1
Building Schools	13	Antelope Creek	1
Church	7	Build America Beautiful	1
Motel	5	Driving Range	1
Waterpark	5	Fountain	1
Hospital	4	Library	1
Nursing Home	4	Retaining Wall & Deck	1

5) What is the average pay a construction worker makes in 1 year?
a) above $50,000
b) $36,500 - $50,000
c) $25,000 - $35,000
d) $10,000 - $24,000

Schools	**a**	**b**	**c**	**d**	
A	2	17	12	2	
B	23	80	140	37	
C	2	17	20	3	
D	1	18	42	20	
E	13	27	38	14	
	40	**159**	**252**	**76**	**527**

6) A construction worker is paid:
a) on a salary
b) different for each project that is worked on
c) hourly

Schools	**a**	**b**	**c**	
A	6	15	12	
B	49	100	136	
C	5	19	12	
D	9	33	41	
E	11	48	32	
	80	**215**	**239**	**534**

7) How are construction workers trained?
a) They must graduate with a degree from a four year college that specializes in their field of work.
b) They must graduate with a degree from a two year college that specializes in their field of work.
c) They must get their Skilled Labor license after a period of apprenticeship.
d) They are hired and then trained in the field by the company they work for.

Schools	a	b	c	d	
A	6	10	7	11	
B	11	54	75	132	
C	2	9	10	20	
D	6	20	17	33	
E	8	27	17	42	
	33	**120**	**126**	**238**	**517**

8) Does your school offer any classes related to construction?

Schools	Yes	No	
A	33	0	
B	240	27	
C	35	5	
D	67	11	
E	86	4	
	461	**47**	**508**

9) If you answered yes to #8, name the class/classes.

Residential Construction/Industrial Tech	344	Industrial Arts	5
Woodworking	67	Automotives	2
CAD/Drafting	28	Electronics	1
Metals/Welding	26	Graphic Communications	1
Architectural Drafting	5		

10) If you had to take an industrial technology class at your school, what would it be?

Residential Construction/Industrial Tech	93	Graphic Communications	12
Woodworking	58	Machine Tool	5
Automotives	52	Carpentry	4
Metals/Welding	33	Would not	3
Architectural Drafting	15	Computers	2
Electronics	13	Industrial Arts	1

11) Would you ever consider a career in the construction industry?

Schools	Yes	No	
A	14	19	
B	114	157	
C	10	31	
D	30	51	
E	37	57	
	205	**315**	**520**

12) If you answered no to #11, explain why (low pay, work conditions, don't know enough about it, etc.)

Not interested	88	Like "thinking" jobs	2
Work conditions	61	Did not think of it	1
Don't know enough about it	47	Don't want to be dirty all the time	1
Low pay	32	I'm delicate	1
Other plans for a career	25	Makes a minority look uneducated	1
Hard labor	24	May not get paid	1
Don't like	23	Not fun	1

Would not be good at it/Unskilled	6	Seasonal job	1
Can get hurt easily	3	The geometry	1
Boring	2	Want a white collar job	1
I'm a girl	2		

13) If you had a friend who was good at/enjoyed working with his/her hands, would you try to talk them into attending a trade school (carpentry, plumbing, etc.) instead of a 4 yr. college?

Schools	Yes	No	
A	16	17	
B	141	126	
C	31	11	
D	34	45	
E	56	40	
	278	**239**	**517**

ASSOCIATE DEGREE PROGRAM STUDENTS 114 Surveys

Short Answer

1) What program are you currently enrolled in?

Building Construction	76	Finish Carpentry	2
Electrical Residential & Commercial	17	Building Materials Mechandising	1
Drafting & CAD Technology	10	Cabinet Making	1
Construction Technology	9	Framing	1

2) What type of classes do you need to take in order to receive a degree from this program?

Drafting/CAD	25	Computers	9
Planning and Estimating	23	Hands-On	9
Brick/Masonry	22	Human Relations	9
Math	19	Carpentry	8
Cabinet Making	18	Personnal Finance	7
Basic Electricity	17	Woodworking	6
First Aid	17	Framing	4
Electrical Wiring	17	Architecture	3
National Electric Code	17	Concrete	3
Accounting	13	Structural Steel	2
Oral/Written Communications	12	Trimming	2
Blue Print Reading	10	Management	1
House Building	10		

3) Who/What was the main influence on you to enroll in this program?

Self/Family/Friends	68	To work with Electricity/interest	1
Like to build	23	Better Job	1
Past Experience	6	Good Field	1
Money	5	Job Atmosphere	1
Received Scholarship	2	Pride in Building things	1
To learn Construction	2	Unable to work in field anymore	1

4) What type of pay do you anticipate receiving upon completion of your degree? (Circle the letter closest to your answer.)

a) $6.00/hr - $8.00/hr ($12,480/yr - $16,640/yr)
b) $8.50/hr - $10.00/hr ($17,680/yr - $20,800/yr)
c) $10.50/hr - $12.00/hr ($21,840/yr - $24,960/yr)
d) $12.50/hr - $15.00/hr ($26,000/yr - $31,200/yr)
e) more than $17.50/hr (more than $35,500/yr)

Schools	**a**	**b**	**c**	**d**	**e**	**f**	
A	2	2	2	5	0	0	
B	4	10	3	4	3	2	
C	5	3	3	2	2	0	
D	2	26	15	16	2	2	
	13	**41**	**23**	**27**	**7**	**4**	**115**

Use the following rating system to answer the following questions. Place your answers in the blanks provided.

1 = excellent

8) Do you find the classes offered to you are more technical related (computers, CAD, electronics, etc.) rather than hands-on construction related (carpentry, framing, metal work, etc.)?

2 = better than average
3 = average
4 = below average
5 = minimal

5) Rank your availability to get into classes that interest you and have significant application to your graduation date.

Schools	**1**	**2**	**3**	**4**	**5**	
A	6	3	1	0	0	
B	11	6	8	0	0	
C	5	4	7	0	0	
D	29	27	4	0	1	
	51	**40**	**20**	**0**	**1**	**112**

7) Rank you satisfactions with the equipment your program makes available to you for coursework.

6) Rank your program's teachers (i.e. 1 = many teachers with a wide variety of field experience, 5 = few teachers, each having minimal amounts of experience).

5) Rank you satisfaction with the equipment your company makes available to you for projects.

A	3	4	3	0	0	
B	7	8	9	0	0	
C	4	6	5	0	0	
D	30	25	6	1	0	
	44	**43**	**23**	**1**	**0**	**111**

SKILLED LABOR 109 Surveys

Using the following rating system to answer questions 1 through 7. Place your response in the space to the right of the question.

1 = excellent
2 = better than average
3 = average
4 = below average
5 = minimal

4) How do you perceive your company's accident record (1 = very low accident rate, 5 = very high)?

1) How do you feel your benefits (job security, insurance, vacation and sick leave, retirement, etc.) compare to that of other construction companies?

	1	**2**	**3**	**4**	**5**	
Gen. Contractor	0	0	2	8	7	
Gen. Contractor	2	4	7	1	1	
Concrete Subcont.	11	26	28	4	4	
	13	**30**	**37**	**13**	**12**	**105**

2) How do you feel your benefits compare to that of other careers?

3) When you are on a construction site, do you feel that the safety regulations you have to follow are adequate enough to make you feel safe?

	1	2	3	4	5	
Gen. Contractor #1	1	2	5	4	5	
Gen. Contractor #2	1	9	2	3	2	
Concrete Subcont.	7	15	25	18	6	
	9	**26**	**32**	**25**	**13**	**105**

7) Overall, what is your opinion of the construction industry's image?

	1	2	3	4	5	
Gen. Contractor #1	1	3	6	5	3	
Gen. Contractor #2	0	3	10	2	1	
Concrete Subcont.	13	18	29	12	3	
	14	**24**	**45**	**19**	**7**	**109**

For questions #8 and 9, select all of the following that apply and place your response(s) in the space to the right of the question.

a) High school industrial technology program
b) Informal training through experience
c) Community College Program
d) Company sponsored program
e) Association (AGC, ABC, etc.) sponsored program
f) Other

8) What type of training did you receive before you began working for the company you are currently employed with?

	a	b	c	d	e	f	
Gen. Contractor #1	10	13	2	1	2	4	
Gen. Contractor #2	5	14	1	1	1	4	
Concrete Subcont.	22	50	8	6	7	19	
	37	**77**	**11**	**8**	**10**	**27**	**170**

9) What type of training did you receive since you began working for the company you are currently employed with?

	a	b	c	d	e	f	
Gen. Contractor #1	1	12	1	1	0	3	
Gen. Contractor #2	0	11	3	6	4	3	
Concrete Subcont.	1	47	5	20	11	23	
	2	**70**	**9**	**27**	**15**	**29**	**152**

Short Answer

10) How did you become interested in a career in the construction industry?

Self/Family/Friends	22	Faith	1
Liked it/Like to work with hands	20	Forced by Law	1
Work Conditions/Work Outside	18	Heard that minorities were hired	1
Experience	16	Job Corps	1
Money	16	Like Working with Big Equipment	1
Needed a Job	3	Needed a Change	1
Did not want to work in a factory	2	Physical and Mental Challenge	1
High School Industrial Class	1		

11) If you could change one thing about your career, what would it be?

More schooling/experience	19	Own a Company/Self-employed	3
Better Pay	16	Recruit Better People to Learn a Trade	2
Retirement Program/Benefits	9	Better equipment	1
Nothing	8	Heights	1
Weather	8	Image	1

Different Job	7	More Challenging	1
Better Position in Company	6	More Versatility	1
Hours	5	Move out of State	1
Start earlier in life	5	Not having to work with Bob	1
Boss	3		

12) What is the highest level of education you have achieved?

12th Grade/GED	36
Some College	32
B.S. College	18
Technical/Associate Degree	11
Some High School/not finished	6
Trade School/not finished	3

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Construction Peer Review: A Technique for Improving Construction Practice

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The potential of the constructor peer review process is examined based on a consulting study involving three separate contractors who undertook to perform peer review analysis of their operations. The stages involving peer review are examined including planning, team selection, data development, site visit, peer review report, report implementation and secondary advantages. Important fundamentals of the peer review process including construction practice examination by non-market competition is covered along with other recommendations based on the study. Peer review as a technique is just that, a technique upon which its success depends on significant resource commitments including time by the contractor sponsor.

Key Words: Construction Operations, Construction Practice, Implementation, Peer Review, planning, process analysis, Review Preparation

Introduction

Construction has become an increasingly competitive business with heightened competition in the marketplace. At the same time, the construction industry has been spotlighted in various texts and reports (Construction Industry Institute, Ogelsby 1989) as having productivity problems in that owners are not getting the required value from their construction expenditures. In addition, construction is a fragmented industry with the vast majority of firms of relatively modest size. Engineering News-Record (ENR) annually features "The Top 400 Contractors." To qualify for the Top 400 List, requires a minimum volume exceeding $47 million (ENR 1995). However, in the United States, those construction organizations furnishing financial information to Dun & Bradstreet number over 500,000 firms (Adrian, 1993). For a manufacturing industry producing complex products that describes construction, it is hard to find parallels between construction and other manufacturers such as are found in autos, steel, chemicals, oil, and electronics. One of the current trends in various industrial segments is that of benchmarking which has been described as "the search for industry best practices that lead to superior performance" (Camp 1989). The construction industry is hampered by a fragmented nature and a lack of data concerning many core competencies. One partner in a "Big 8" accounting firm stated that of all the businesses that their firm deals with nationally, construction businesses were singularly unique in lack of key data on various business elements (Beadle 1992). One of the few areas in which publicly available data is available is the area of estimating. There are a number of organizations that publish estimating data on a national basis for the construction industry (Walker's, Means, Richardson, Saylor 1995). One drawback to these estimating publications is that they are averages. A more troubling aspect is when tabular estimating data between publications is compared with resultant wide discrepancies (Jelen, 1983). Given the fact that construction is highly competitive and most firms work in a local or narrow-scope regional area, there is a reluctance to share best practices amongst contractors (McLaren 1992). Construction firms feel quite naturally that sharing best practices with competitors will simply make themselves less competitive. The question becomes one of how do construction firms improve their practices? Obviously, books, seminars, and other continuing education avenues are available for construction professionals. Often, these sources, in order to appeal to a more general construction audience, are themselves general in nature. The construction firm seeking to improve is confronted with a dilemma on where to go to find practices to emulate.

Constructor peer review can provide a solution to providing ideas for improved practices. Key personnel from other construction firms visit the subject construction firm and provide a thorough analysis of current practices and recommendations for improvement. To avoid the competitive problems enumerated above, peer review personnel are specifically selected from outside the construction organization's geographic market area. The benefits of this process accrue to both the firm studied as well as the peer reviewers themselves. This paper results from three consulting assignments by the author where the peer review process was developed and completed with a high degree of success (Opfer 1995).

Peer Review Fundamentals

Improving construction practice is essential for the long-term survival and profitability of the construction firm. It is not for every firm, only those that want to seriously improve themselves. Firms have in many cases spent significant sums improving minor items without significant results. Other firms have started improvement projects and floundered due to lack of guidance. Constructor peer review can help firms avoid these problems by finding the mission critical items to improve and how best to achieve this improvement.

However, effective peer review is not just about visiting construction firms. Otherwise, unorganized and unplanned peer reviews can end up just being "construction tourism" in which participants have fun and trade "war stories" but there is a lack of meaningful analysis along with resultant benefit (Hastings 1994). Part and parcel of the peer review process must include front-end planning, development of contractor data, peer review team selection, and peer review team report in addition to the site visit. Failure to provide adequate focus on all steps of the process can reduce the chances for success of the constructor peer review process. Breaking down barriers to open communication is another impediment to success in the process. In part, geographic diversity will help to foster open dialogue. Constructors need to be open in communicating their thoughts and work as a team to be successful. Unfortunately, many constructors are of the independent type and not used to teamwork but instead secrecy amongst competitors and an adversarial environment that clouds many construction projects. Part of the directive for open communications must be that peer reviewers do not ask for information on a firm's practices that they would not be willing to provide peer reviewers about their own firm on a subsequent peer visit.

Egotism amongst many in the construction industry is a key barrier to implementing constructor peer review. There are those that when certain improved ideas come along feel that this is fine but "my work is different" (Ogelsby 1972). The author has seen this attitude exhibited in many instances over the past two decades of work in the construction industry. In 1974, interviewing two medium-sized contractors in the same market area about whether they utilized critical path method network techniques produced an interesting response. The highway contractor thought that "CPM was a good technique but was really suited for building construction projects" whereas the building construction contractor felt "CPM doesn't work on building jobs but is good for road projects" (Kuney, Degerstrom 1974). Some contractors already feel that they are utilizing the best practices since they have state-of-art software for estimating, scheduling, and cost accounting/control along with the latest field construction equipment. While this may be true, how software and other equipment is utilized along with the business practices that support it is what can be determined from constructor peer review. Peer review can also pinpoint the appropriateness of a given solution to the needs of the individual construction organization. Sales representatives selling computer software or construction equipment are interested in selling product and will push their available solution when a contractor need could be better satisfied by another route.

Peer Review Planning

The decision to implement peer review is followed by front-end planning. This planning should fit within the framework of the construction firm's overall strategic planning process. Specific target areas should be identified as those to be subjected to peer review. Top contractor management needs to be supportive of the peer review process as bottom-up methods are prone to failure. Part of the planning process includes identifying mission-critical core areas essential to the contractor's success. These mission-critical items usually include such areas as business development, cost estimating, purchasing, project management, equipment management, and subcontractor management. Deciding what is mission-critical and what is not should be driven by four tests:

> The item should be difficult for the contractor's competition to emulate The item should be a key factor in the contractor profitability The item should be a key factor to clients in contractor differentiation and perceived value by the client The item should be of a quantifiable nature or aspects of the item quantifiable if possible.

An item can be mission-critical for the contractor and not meet all four of the tests. The more an item fits the four test criteria means the more importance that should be placed on that item. This planning process is a difficult and unfamiliar ordeal for most contractors. As one observer stated, "most contractors spend more time planning the company Christmas Party than what they are planning to do in the next year" (Trease 1993). In tandem with the front-end planning, development of prospects for the peer review is necessary. Initial conversations with these prospects can help to focus the planning process. Part of the front-end planning should involve process modeling involving materials and information flow for the contractor. Who is the customer of the particular process? In the case of an estimate, this has both an internal and external focus. The external customer is the client receiving the estimate while the internal customers may be the purchasing agent who buys out material for the project along with field management who utilizes the estimate in cost control functions. A civil/structural contractor on foundations has as an external customer the construction manager/general contractor they are contracted to and an internal customer in their own steel erection crew installing columns on the foundations and anchor bolt assemblies. Poor quality on foundation anchor bolt alignment causes subsequent cost problems in steel column erection. Inputs and outputs for these various processes can be analyzed during the planning process.

A cautionary note is in order in that the proper amount of time needs to be spent in planning for peer review. Trying to perform this front-end work in a week or a day will not suffice. The press of other work gets in the way and what can be postponed does get postponed "until tomorrow or next week." The person or team responsible for this planning should have familiarity with those areas under consideration. Since construction involves a mix of field and office processes, the person or team should have an appropriate experience mix. At the same time, the planning process should not be allowed to continue indefinitely. Schedules should be established with realistic milestones. The person or team should be given release time to accomplish their work in a quality fashion. Due to the hectic pace and understaffed nature of many construction organizations, several sessions spread over a number of Saturday mornings may be appropriate.

Peer Review Team Selection

Successful implementation of the peer review process depends on sound selection of team members. To ensure open communication and avoidance of competitive secrecy, these members should be selected from outside the contractor's geographic operations area. Constructors in their travels to other areas of the country should be looking for possible other constructors to participate in this process. Contacts through members of professional or trade associations such as American Institute of Constructors (AIC), Associated Builders & Contractors (ABC), or Associated General Contractors (AGC) can be very useful in developing possible names. An AIC, ABC, or AGC Chapter President, for example, may be able to put a contractor in contact with those in other geographic areas. Contacts at annual meetings and seminars of associations can be productive as well in establishing contacts. Construction services providers should not be neglected in this process. While the construction firm operates on perhaps only a local level, services providers such as accounting and surety bonding firms operate on a national basis. Conversations with a transplanted surety bonding agent or construction accountant new to an area may pinpoint possible progressive contractors in another market area for potential contacts. Disclosure of confidential client information should not be demanded but instead asking whether or not these contractors are successful should suffice for initial selection purposes.

Ethics in the constructor peer review process is an important criterion. If a team member has a potential conflict in that a relative in the contractor sponsor's locale works for a competitor, selection should be avoided in this instance. A potential team member may be planning to be employed by a competitor in the same locale that would provide disqualification grounds. All potential team members should be informed of ethical considerations.

Once constructor peer reviewer names are selected, initial contact can be via telephone. If subsequent upcoming personal contact at a convention or other meeting can be arranged, this can prove useful. Successful peer review selection should be a win-win process for all parties involved and this needs to be clear at the outset of the selection contact process. Travel is expensive and the firm being peer reviewed should compensate the travel costs for the involved constructors. The time away from their work is also a consideration and can be compensated by an honorarium or hourly rate depending on the particular agreement. Upfront explanation of expenses and compensation can ensure that this is a serious effort on the part of the contractor sponsoring the peer review.

Besides compensation for the reviewers, other benefits need to be highlighted which accrue to them as a result of the review. Peer reviewers get to see the inner workings of other contractors and bring back new ideas to their own firms. Peer reviewers get a better perspective in that many firms have the same common types of problems. A peer review visit may help the peer reviewer avoid problems previously encountered by the contractor sponsor. A well-organized peer review can be continuing education for the involved constructors.

Constructors should be selected based on types of experience and firm types of work. A building contractor would want to ensure that a building contractor is represented on the team. However, contractors should not be too parochial in this selection process. An electrical contractor may have business practices that could provide sound examples to a general contractor. By aspiring only to be the best in its narrow area, "a team can set a cap on its own ambitions" (Hammer 1993). The other side of the coin is that before concrete commitments are made, resumes of potential peer reviewers should be evaluated by the contractor. A particular construction firm may be recommended as outstanding and deserve this reputation. However, a particular individual with that firm may have a relatively narrow and/or minor role with the firm. Constructors should be selected with a view toward overall experience. Thus resumes with further follow-up telephone interviews can help to avoid these situations. The aim is to recruit the best peer reviewers possible. The odds are that the perfect constructor reviewers cannot be found which leads to another concern. The selected team should be balanced in its composition. A four-member team with three estimators and one accountant would in all probability not possess the necessary balance. Selection of the number of team members will be dependent on areas identified in the front-end planning process for study.

The size of the selected team will usually consist of three to five reviewers. A smaller team usually will not have all the necessary areas of expertise. A larger team than five members can prove too unwieldy and unworkable. In part, team size can be governed by complexity of the contractor's operations. A general contractor self-performing a significant portion of their own work involved in several distinct types of work and including a design-build function is obviously more complex than a general contractor that self-performs no work and just builds strip shopping centers and small offices. The contractor sponsor should designate a team captain from amongst the constructors selected to perform the review. The team captain will be responsible for coordinating the observations and data gathered during the site visit into a peer review final report. At least two alternates should be selected for the team. If one peer reviewer becomes ill or is unable to attend due to family emergency, the alternate can be a substitute. As an adjunct to the team, the contractor sponsor should supply secretarial services to document the substance of conversations and discussion. Secretarial services avoid the distraction of team members for note taking and allow reviewers to focus on analysis and observation. As soon as possible, a transcript of the visit should be word processed and sent to the peer reviewers to assist in analysis and compilation of the final report. Some contractors have the secretarial services on overtime to produce the current day's notes for immediate team member distribution the following morning.

Contractor Data Development

From both the planning process and team member interview, areas for data development can be determined for the peer review. Peer review is a comparative process where constructors compare their own firms with the contractor undergoing this evaluation. A comparative process demands data as a necessary input. Ideally, before the actual site visit, requested data and documents can be sent to team members prior to the review. In the accounting area, sample copies of sales journals, cost reports, payroll reports, and general ledger areas may be requested in necessary data development. Financial ratios such as current ratios, average collection period, and return on assets are other areas. Business development data needs include clients and type, firm image evaluation, expenditures on advertising and promotion, competitive analysis, and substance of direct sales efforts. Field management evaluation can include accuracy of work-in-progress schedules, materials procurement cycle times, equipment utilization, change order processing procedures, and safety records.

In data development, the six questions to be answered include who, what, when, why, where, and how. Data development is a costly but essential aspect of this peer review process. Ensure that a dollar isn't spent to gather a nickel's worth of data along with ensuring that necessary data is made available. The level of detail should be in summary form to avoid bogging down team members in minute details. Once problem areas are identified, further analysis can be performed by internal contractor personnel. Data gathering can be inhibited by poor communication by the contractor sponsor. The firm's internal personnel should be informed that data are being gathered for the peer review. The review is not being conducted with the agenda in mind to terminate anyone. Rumors can quickly spread given a lack of communication within the firm. Usually any redundancies found result in the redeployment of personnel to other necessary areas and not in the elimination of personnel. Someone who feels their position may be eliminated will be reluctant to fully cooperate in the peer review process. It should also be emphasized that people are not being examined but instead management practices.

During contractor data development, the firm may find areas for improvement even before enacting the peer review process. As data is gathered, the contractor should be analyzing four areas as to whether: existing reports are inflexible or ill-timed existing reports impede change existing reports serve some areas at expense of others existing reports are irrelevant.

Existing data collected may be too late in the process to be of use. A peer review may find that a cost report meets necessary criteria but the timing of the report is two weeks after field costs are incurred which can make its use in cost control efforts debatable. Or a particular construction process or project may demand a different type of cost report which can not be provided by the existing system which leads to non-optimal results. Some existing data in reports is too weighted towards cost at the expense of quality and client satisfaction that can impede the contractor's long-term change efforts. Data demands on field-level construction personnel are intense but all information flows are bottom-up and little is top-down. Some data is compiled which no one in the firm may know why it is reported save for the fact that "it's always been done this way." Peer reviewers can force justification of these reports and should be supplied with copies of all reports with explanation and justifications for each report along with report timing. Various processes can be broken down in data development with flow charts delineating various areas where data comes from and where it goes for the contractor's operations. The end goal of data development, of course, must not be lost sight of which is that of process improvement.

Peer Review Site Visit

Scheduling of the site visit may want to avoid a period of heated activity for the construction firm. This may be during the late fall or winter months for most firms as operations in many areas of the country are on a reduced schedule. At the same time, a survey of operations should be realistic and not when the workload is atypical. Sometimes contractor practices can change depending on workload. Stress points and the impact of bad practices or practices not followed are often more prevalent with high activity levels. Peer review can be a catalyst in pinpointing these deficiencies. The above factors should be taken into consideration in scheduling an optimal time for the peer review.

The time allotted for the site visit should be sufficient to allow for both face-to-face exchange and discussion along with an adequate analysis/observation of targeted areas. The team can split up to allow focus on both field and office operations of the contractor based on their respective areas of expertise. At least two full days should be allowed for the constructor peer reviewers. Depending upon operational complexity and number of areas to be studied, additional review time may be necessary. The key driver in this process is that both peer reviewer and contractor personnel time is severely limited in amount. An organized process with reviewers pre-supplied necessary reports and data before the visit can improve the productivity of the encounter. Key people in the contractor's organization should be identified and scheduled on the agenda beforehand. A scheduler may only be needed for an hour or an equipment manager for two hours. Regardless, the time should be allocated on the peer review visit agenda. Since the contractor has to maintain continuing operations, contractor personnel should be scheduled efficiently.

A peer reviewer team room can be set up by the contractor to facilitate the process. Often this room ends up being the contractor's conference room. If room is not available, some contractors have utilized an unused office trailer cleaned up, brought in for the occasion and parked next to the main office. The team room should be taken seriously and not as an afterthought with a viewpoint towards providing convenience and productivity for the peer reviewers. Computers, printers, copiers, faxes, phones, and other office equipment should be provided as necessary. A split field/office team should be accommodated with additional secretarial services. The presence of note taking can inhibit dialogue in certain instances. Thus the peer reviewers may be supplied with outside-the-firm secretarial services. Again, confidentiality of information is of key concern to contractors. Thus some contractor sponsors have brought in these secretarial services also from outside the relevant geographic area. While this practice may seem unnecessarily costly, given the total costs of the peer reviewers plus contractor's personnel time costs, the additional marginal cost for outside secretarial services is relatively minor.

Before the peer review team leaves the contractor's site, an exit conference should be conducted between the team members and contractor top management. This provides a final opportunity to ask questions and clarify any misunderstandings on the part of team members. One purpose of the exit conference is to ensure no surprises in the final peer review report. The final report will not have been completed (except in basic outline form) by the time of the exit conference but its substance and its recommendations in summary form are made available to the contractor sponsor. During the site visit, additional information may have been promised to the team by contractor personnel that is still lacking by exit conference time. Conference discussion can serve as a reminder of the needed data. The tentative schedule for final report production is also scheduled at this conference.

The contractor should initially send each selected member a planned agenda and trip itinerary. Additionally, hotel arrangements at one hotel for the peer review team should be made and paid for by the contractor sponsor. Hotel selection should have convenient access to the contractorÆs business and the single hotel allows additional peer review interaction during off hours. Once the team is on location, arrangements for expenses should be completed promptly.

Peer Review Report

The peer review report is submitted at an agreed-upon time after site visit completion. The team captain is responsible for the production and distribution of the report. The report should communicate the findings of the peer reviewers in sufficient detail for action steps by the contractor sponsor. The findings should be accompanied by recommended courses of action to improve its practices to achieve peer reviewer recommendations. If possible, additional cost implications of possible action steps should be highlighted for the contractor. The peer review report will typically recommend change in a number of areas of the contractor's operations.

Sound peer review reports avoid generalities and focus on specific concrete action steps. Areas for improvement in the report consist of targets. However, not all goals are quantifiable; some may be qualitative in nature. Qualitative goals by their very nature present measurement problems. Insistence that everything the contractor does be by the numbers with quantitative targets is unrealistic. Similarly, the impact of uncontrollable factors must be taken into account. Targets for a residential builder/developer on a 200 unit subdivision with build-out 20 homes at a time will be impacted by external factors such as the local economy and interest rate levels. This will have a significant impact on whether certain targets may be met for the subdivision operations. If possible, the peer review report should have realistic timetables attached to the targets. Some targets may have a timeframe of one month for accomplishment whereas others may take six months to a year depending on the magnitude of the item.

The contractor may want to have two reports. The primary or main report covers all detail on an in-depth basis for internal consumption only. An executive summary of the main report may be produced in summary form for the reasons listed below: attachment to business plans when seeking bank loans provided to surety bond underwriters for bonding evaluations included in client packet as part of business development/marketing efforts.

Naturally, there needs to be judgment and discretion utilized in making the plan or parts of the plan available to a wider audience than those internal to the firm. Whether, distribution of the report in an executive summary is done depends in large part on what is contained in the report.

Other Peer Review Advantages

Besides improving construction practice, there are other benefits to the contractor undertaking peer review. Some of these additional advantages may be just as important as improving construction practice.

Contractors in marketing their services to clients are continually looking for ways to differentiate themselves from the competing crowd of contractors. The fact that the contractor is making efforts to improve their delivery of construction services through the peer review process should be made known to existing and potential clients. Stories in the popular press abound on disreputable practices of some contractors. Constructor peer review highlights that this contractor is serious about improvement and not just looking for the "fast buck."

Financial institutions and surety bonding firms look for professionalism in a contractor's operations before granting credit lines and bonding lines respectively. The peer review can pinpoint improved practices but, in addition, the fact that the contractor is seeking improvement makes a positive impression on these firms. Complete copies of the report may be provided to the contractor's accounting firm additionally for their assistance and subsequent evaluation of the contractor.

Avoidance of litigation is a continual concern for those in construction. The contractor in its use of various contracts and other documents may be open to lawsuits because of weaknesses inherent in certain documents. The contractor that states "this document has been used by us for twenty years with no problems" may not realize their potential legal liability until the item is scrutinized during peer review (Harrison 1994). In providing certain services that result in a lawsuit, the contractor is held to the "reasonable standard of care" rule. Courts do not expect contractors to walk on water but to exercise a reasonable standard of care in their operations. Successful peer review can provide additional evidence that the contractor is adhering to a reasonable standard of care in their work.

Peer Review Report Implementation

While the mere fact that the contractor has undergone evaluation is a positive factor in and of itself, implementation of the peer review report recommendations is essential. There may be problems with this. The vast majorities of contractors are family or closely held businesses (Morris 1992). One problem with the family or closely held contractor is that of a certain amount of personal pride and emotional investment in various practices. A practice started by the contractor's founder, now outdated, may still be in use because "that's the way we've always done it." Report implementation must recognize these barriers and start gradually. Perhaps small modifications in certain areas or pilot projects are all that is initially possible.

Successful report implementation will depend on the buy-in of all participants in the particular operation. Top management support is obvious but achieving the support of all those impacted by the required changes in the contractor's continuing operations is ignored sometimes. Due to the interdependent nature of many construction operations, coordination problems should have input by those directly involved subordinates. One of the important principles of the TQM movement is seeking involvement in decisions for those directly affected (Jacobson 1986). Some of the report recommendations may require a coherent package of changes rather than independent solutions to particular problems. To ignore this need for coherence in certain areas can ensure a non-optimal result in many instances. Tracking of progress towards peer review recommendation should proceed on a regular basis.

Implementing practice recommendations means investing time, money, and other resources. All of these are limited. Therefore, focus needs to be on those areas that promise the highest return to the contractor, given that the above caveats on interdependence and coherence are recognized. The changes to be successful usually require a certain package of minimum resource levels and not "what the budget will allow" for the contractor. The mistake that contractors can make in report implementation is in throwing too few dollars at too many projects. To be effective, choices have to often be made by the contractor.

Summary

Contractors face highly competitive construction markets in the current environment. Gaining a competitive edge over rival contractors is a continual challenge made more difficult by the secrecy, lack of data, and fragmented nature of the construction industry. Constructor peer review utilizing resources from outside the contractor's competitive geographic arena can provide solutions for improving construction practice. Besides the primary goal of improving construction practice, other benefits in marketing, legal, financial, and surety bonding areas can accrue to the contractor. Peer review provides the additional benefit of highlighting certain areas for improvement that the contractor previously may not have recognized as improvement candidates. To be successful requires a substantial commitment by the contractor not only for the peer review visit but for planning, data development, reviewer selection, and report implementation. Peer review should focus on the concept of construction systems which takes a broad perspective. An important point about those components of the construction system is that they are all integrated; trying to make a change in one dimension will change the others.

The constructor peer review process is not a "magic bullet" that will help a contractor with all problems. Problem identification is dependent on the quality of the reviewers and their efforts. Solution implementation coincides with the ability of the contractor to make the required changes given resource limitations and other constraints. Certain macro environmental problems for contractors such as taxation, regulatory agency impact, declining markets, and growth restrictions are beyond the scope of peer review.

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Construction Scheduling Specifications

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General conditions found in construction contracts deliberate the managing procedures for construction projects, such as whether schedules are updated and cost loaded. These contract clauses should encourage management participation through a balance between closed specifications with specific requirements and open specifications that allow the parties of the contract to use management procedures that they are comfortable with.

Key Words: General conditions, specifications, schedules, updating, cost loading.

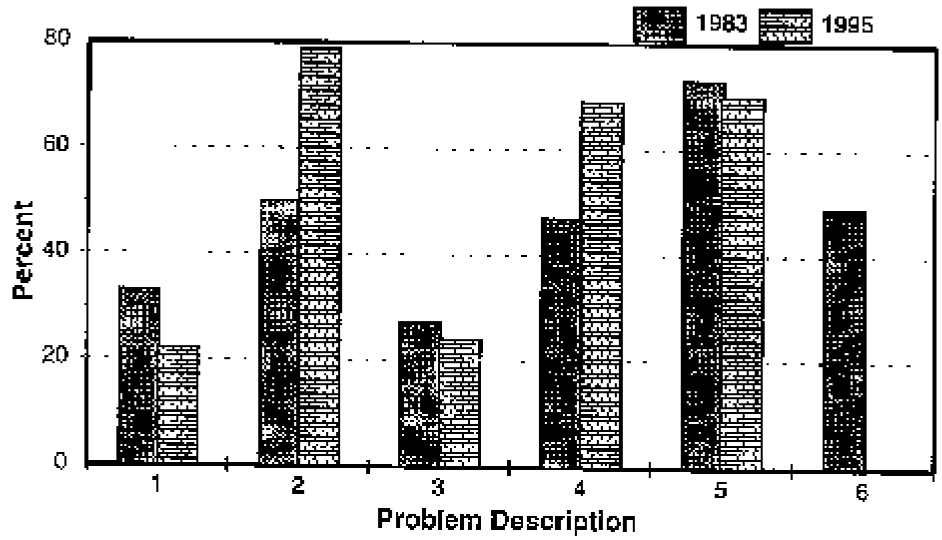
Introduction

Schedules are management tools for planning complex construction projects and coordinating the work of the architect, owner, contractor and subcontractors. Although many contractors develop an original planned schedule, many aspects of a comprehensive schedule such as cost loading, are used less frequently.

This article identifies the contractors’ preference level for the requirements found in scheduling specifications. In this study, questionnaires were faxed to 141 contractors to measure the preference for the different types and techniques of scheduling in the construction industry. From the 41 responses, the contractors’ preference is compared with responses from an earlier survey and many of the current standard scheduling specifications.

The Schedule's Affect on Delays

The general conditions in the American Institute of Architect’s (AIA, A201) paragraph 8.2.1 asserts that "time limits stated in the Contract Document are the essence of the Contract." A 1983 study demonstrated the importance of schedules in relation to completion time. This survey compared projects completion dates when contractors used a schedule and when contractors didn’t use a schedule. The survey reported that contractors who used CPM schedules were late on 27% of their projects. For contractors who did not use a CPM, the late project rate rose to 44%. The first set of columns in Figure 1 is from the original survey in 1983. In 1983, scheduling attributed to a 17% increase in completing a project on-time, which is shown in comparing columns 3 and 4.



1. Projects completed behind schedule
2. Contractors who use scheduling
3. Contractors who use scheduling
4. Contractors who do not use scheduling and finish job late
5. Poor schedules cause overrun
6. Project late and project dispute job finished late

Figure 1. Scheduling and Project Completion: 1983 vs. 1995

The second set of columns in Figure 1 was generated from the questionnaire taken in 1995. All of the questions except for the sixth question were repeated in the 1995 questionnaire to compare the results twelve years after the original study. It can be seen that the use of scheduling has increased between studies, from 50% to 79%, as shown in the comparing the second set of columns (2). Although this is a significant increase, the introduction of computer technology over those same years is more dramatic. Other trends shown in the study include:

?? Construction projects completed behind schedule have dropped by more than 10%. A comparison of the first pair of columns shows that 33% of all projects finished behind schedule in 1983, decreasing to 22% in 1995.
?? The pair of columns labeled three show that contractors who scheduled projects but the projects still finished late remains at about 25% over this time span.
?? The fourth pair of columns indicate that contractors who do not use scheduling for projects and the projects finish late have increased by more than 20%.
?? The results of late projects are shown in columns five and six. Poor schedules cause cost overruns about 70% of the time and late projects result in project disputes about 50 % of the time. The current study found the cost overrun data about the same and did not repeat the disputes question.

Certainly the increase in contractors who use scheduling and the drop in projects completed behind schedule is an encouraging trend. The disturbing trend is the large increase in late project completion for those contractors who do not schedule. This may be due to increased time pressures and the complexity of the projects. This emphasizes the need for construction management to schedule projects. Managers must recognize the need, purchase the software, train their employees, and encourage the use of updated and cost loaded schedules.

Closed or Open Specifications

Rather than leaving the choice to the participants, some specifications dictate requirements for the method of scheduling.

These requirements include the frequency of updating, the use of cost loading, the number of activities, the type of schedule, and even the type of software, just to name a few. These are closed specifications, in that they detail the specific procedures for managing a schedule.
The AIA A201 scheduling process has few procedural statements and is predominantly an open specification, which obligates the contractor to derive a schedule (A201, 3.10.1), but leaves the scheduling details up to the contractor. The specification is:

> The Contractor, promptly after being awarded the Contract, shall prepare and submit for the Owner and Architect's information a Contractor's construction schedule of the Work.

Additional scheduling obligations can benefit project control through managerial involvement:

> Detailed clauses attempt to impose a particular scheduling technique or regulate the complexity of the schedule. General clauses permit Contractor flexibility in selection of technique and complexity. The AIA philosophy to take hands off and run away bespeaks the problems its members and its insurers have had in the recent past with construction delays. There is thus some justification for a scheduling clause with greater detail than the AIA's.

On the other hand, many contractors preference for closed scheduling specifications supports the hands off position of the AIA. Figure 2 shows low contractor support for contract clauses that dictate how the contractor prepares the schedule. Eighty-five percent of the contractors surveyed support the specification for an original schedule. However, other detailed scheduling specifications are much less embraced. There is little support for specifications requiring a schedule with progress payments (22.5%) or specified updating procedures (17.5%), and virtually no support for specifying the type of schedule (2.5%) or cost loading the schedule (2.5%). There are many reasons why a contractor may prefer a less detailed schedule. Detailed schedules are more expensive to produce. Proprietary information can be hidden with a less detailed schedule. Also, some contractors circulate early start schedules as a stimulus to subcontractors. History has shown that contractors preference can be changed by adopting closed specifications that direct implementation of better business practices, as exemplified by the Gantt Chart. Henry Gantt, a Maryland management engineer, invented the Gantt Chart to allow foremen to study the performance of their equipment. The chart was adopted by the military, who changed the focus from adjusting machine efficiency to managing the shipment of materials. Before World War II, about 12 companies used the Gantt Chart. After the war, there were about 1200 companies using Gantt Charts as a result of a military requirement to suppliers.

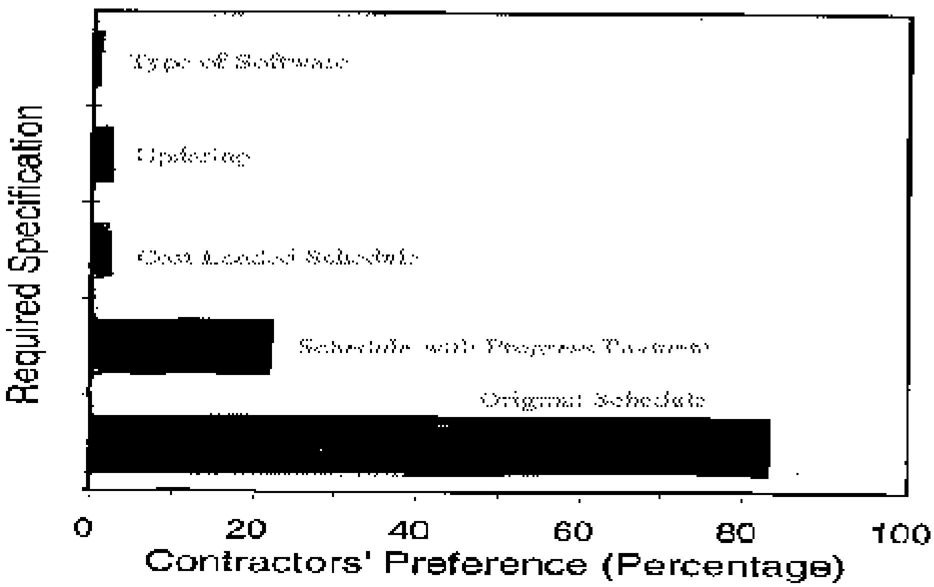


Figure 2. Contractors Preference for Required Scheduling Specifications

Table 1 shows the present circumstances with cost loaded schedules. Although scheduling software provides the technical ease to cost load schedules, only 20 % of all schedules are cost loaded. The low contractors preference of 2.5 % contributes to the low number of cost loaded schedules. One contractor commented that he cost loaded only government jobs because most of them specified cost loading. Since the technology is already in place, it would be beneficial for this company to utilize cost loaded schedules for all projects.

Table 1

Cost Loading of Schedules

Cost Loading Scheduling Situations		
Description of Circumstance	Yes	No
Contractors Preferred	2.50%	97.50%
Specifications Required	7.10%	92.90%
Project Schedules Cost Loaded	20.00%	80.00%

The risk that can be avoided through the use of cost-loaded CPMs with monthly cycles ... are substantial. On the one hand, this technique prevents the parties from putting off a lot of little claims regarding changes and delays until the end of the project. When this is done, many small problems which could have been easily addressed at the time they arose tend to become one big problem, and the owner often ends up in a dispute with the contractor regarding a large overrun of total construction cost.

Scheduling Requirements

Table 2 reveals the inconsistency in the construction industry with regard to scheduling specifications. The documents compared are the *American Institute of Architect's (AIA) Document A201 - The General Conditions of the Contract for Construction*, the *Associated*

General Contractors (AGC) Document 510 - Standard Form of Agreement Between Owner and Construction Manager and 600 - Subcontract for Building Construction, 1988 State of California DOT Scheduling Specifications, Engineers Joint Contract Documents Committee (EJCDC) Standard General Conditions of the Construction Contract, and the *United States Postal Service Specification (Section 01030*.

Table 2

Scheduling Requirements

Document	**Original Schedule Deadline**	**Software or Format Specified**	**Approval Time and Procedure**	**Update Requirement**
AIA A201	Promptly	None	None	at appropriate intervals
AGC 510 (CM)	In design phase	None	None	Yes, but not specified
AGC 600	Provide Contractor with any requested schedule information	None	If interrupted resume in 2 days	Yes, but not specified
CA DOT	20 days after contract is signed	None	No progress payments until the Engineer is satisfied	within 10 working days of the Engineer's written request
EJCDC	10 days after NTP	None	10 days before first progress payment	to reflect the impact of new developments
US Postal Service	35 days	Primavera	7 days CPM-Cost & Resource Loaded	monthly

Construction contract provisions vary in the specified time periods for administering the original schedules. For the above contracts, the original schedule is required "promptly," "in the design phase," "after 10 days," "after 20 days," and "after 35 days." Any of the mentioned due dates for the original schedule can be met, but the detail and accuracy of the schedule after 10 days may be less than a schedule created after 35 days because of time constraints.

It is unusual for specifications to delineate the amount of detail in the schedule. Five of the six specification clauses shown in Table 2 do not specify the type or detail of the schedule. The most prevalent specifications in the construction industry, the *AIA*, the *AGC,* and the *EJCDC s* schedule specifications are not detailed. In contrast, the U.S. Postal Service, and other government agencies such as the U.S. Veterans Administration, uses specifications that include the type of scheduling software, the number of activities, the update frequency, and the type of graphical representation. The format of the schedule is usually based on the personal preference of the contractor. Contractors prefer the bar chart by far, as shown in Figure 3. Although activity-on-arrow and activity-on-node are both formats in Critical Path Method (CPM), CPM was included in the questionnaire as a separate format. The CPM format was included to diffentiate those contractors who included float and critical path in the schedule presentation.

Contractors update their schedules at different intervals. The AIA A201 states that The schedule... shall be revised at appropriate intervals as required by the conditions of the Work... This allows for an open interpretation of when the schedule is updated. Most of the current general conditions follow this open interpretation of updating. Update requirements also are varied, taking place "within 10 working days," "monthly," or "to reflect the impact of new developments." The CA DOT requires a notice requirement in updating, within 10 days of Engineer s written request as compared to the US Postal Service s monthly requirement.

Specifications are needed on construction projects to maintain feedback to management in this interactive process, and a balance must be struck between providing an adequate amount of information and updating too frequently.

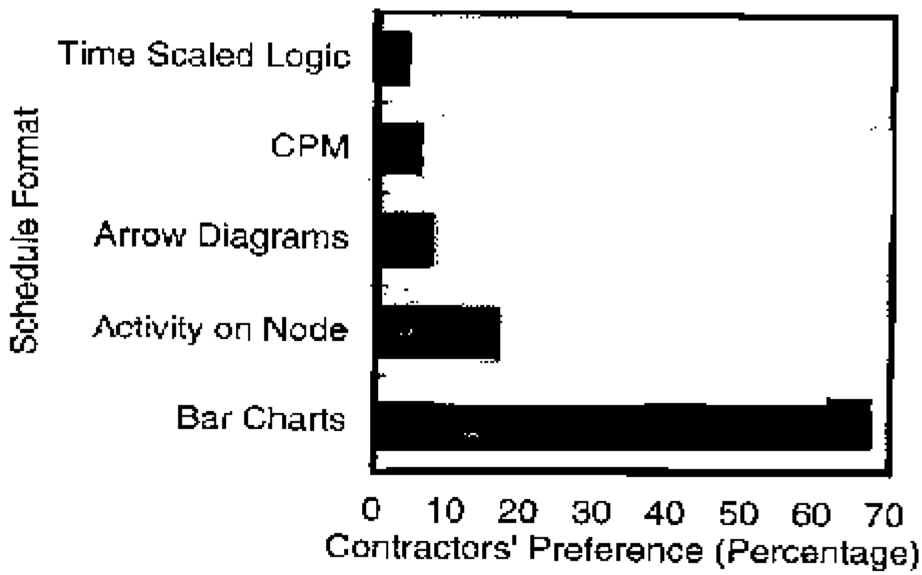


Figure 3. Contractors Preference of Schedule Format

From the faxed questionnaire it was found that almost half, 48.8%, of the contractors updated monthly as indicated in Figure 4. Other contractors updated their schedules at more frequent intervals; 27.9% weekly and 18.6% bi-weekly. Only 5% updated less often than monthly.

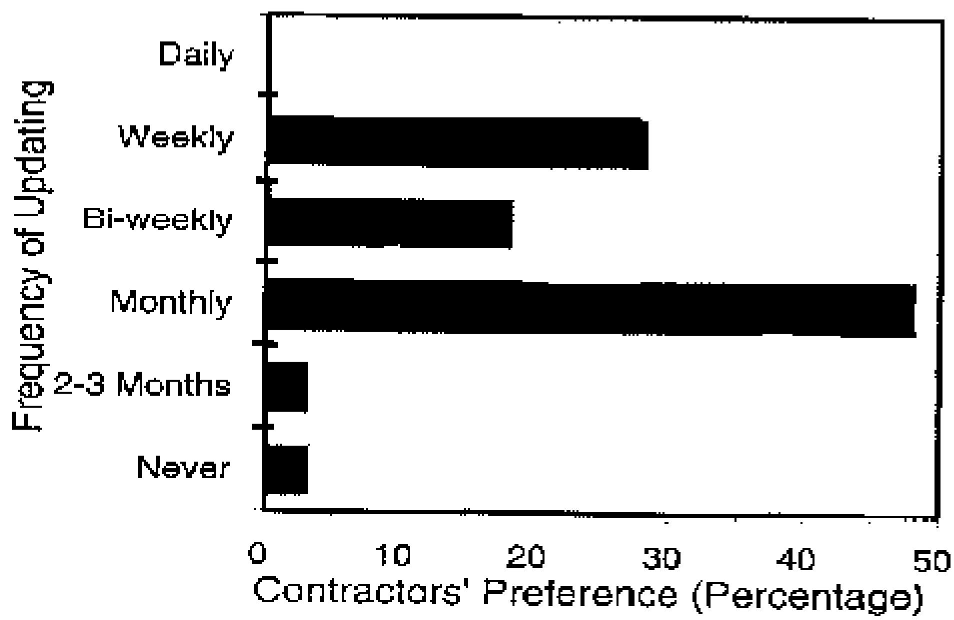


Figure 4. Frequency of Updating

Perhaps specifications need to become more specific when evaluating the effect of changes to the schedule. The Corps of Engineers, who stipulate simple bar charts in their contracts, employ network analysis for a more detailed identification of the impact of changes. The complexity of the project may be a determining factor to scheduling administration specifics, such as the updating frequency.

Obligations and Opportunities

Scheduling provisions are both an obligation and an opportunity. The contractor is obligated to prepare the schedule. The schedule is submitted to the architect or owner, establishing that project performance was agreed upon by all parties. For a contractor who schedules a two-year project for one and a half years, he forecasts a one-half year float. This scheduled finish date exhibits the contractor's intention to complete the project early and substantiates the right to receive prompt payment upon early completion. Federal law grants contractors the right to complete the project earlier than the contract completion date and the schedule forewarn the owner of an obligation for early payment.

In the case of Pathman Construction Company (Pathman Construction Company v. United States, ASBCA 14285, 71-1 BCA Par. 8905, 1971), the project's schedule was accelerated based on a government representative's statement of urgent need along with the revised schedule verifying the accelerated performance of the change claims. The revised schedule was submitted, in response to the representative's statement, with an early completion date. This request, coupled with a threat to access liquidated damages, constituted a request for accelerated performance and the need to compress selected project activities to reduce the project's duration. The court relied on the schedule and found for the contractor.

The failure to grant time extensions in a timely manner can compromise an owner's position. Fortec Constructors submitted a claim for cost and time extensions to the Corps of Engineers (Fortec v. United States, 8 Cl. Ct. 490, 1985) for unilateral modifications on an aircraft maintenance facility. The court found that the Corp's denial of the cost and time extension was improper because the Corp had based its decision on an original schedule. Control of the project is hindered when the schedule is not current.

Construction management has become much more sophisticated with network analysis of updates easily incorporated into computer schedules. Extended durations and changed conditions are recomputed in minutes. With an interactive scheduling procedure, the project's time and the effect of changes to the project are instantly updated. The revised "what if" schedule predicts the consequences of significant changes to the as-planned "original" schedule. "What if" schedules are easy to generate with today s software, and managers should directly encourage interactive analysis as the construction norm.

Developing Schedule Specifications

Scheduling is a form of programmatic goal setting and feedback, which can increase productivity by up to 20%. Open scheduling specifications, such as the two paragraphs in the AIA specifications, allow flexibility to the contractor. But at the outset of the project, parties should clearly specify how performance will be measured, including the type of scheduling software, the number of activities, the update frequency, and the type of graphics. Experience has shown that the more detailed the specification, the better the chance to eliminate misunderstanding. For large complex construction projects, scheduling software is of immense value as a planning tool, reducing uncertainty in managing the project. Similarly, closed specifications standardize administrative procedures and reduce heated debates resulting from unplanned events.

Insisting on a closed specification that dictates the updating requirement may be found by contractors to be annoying and meaningless. The Veterans Administration s Network Analysis System (Section 01311) is over a dozen pages long. Many construction projects do not require this amount of detail. A balance must be struck between more information versus more paperwork. It is not complex but efficient scheduling that reduces confusion, lessens conflict between the parties, and maintains focus on the project's completion.

Clearly defined administrative procedures promote smooth contractual resolution, just as construction scheduling promotes harmonious project flow. Scheduling specifications should address not only the format, updating, and cost loading; but procedures for justification of time extensions, float utilization, involvement of subcontractors, and remedies for noncompliance. Lack of specified administrative procedures can exacerbate the project efficiency, whereby contract administrators may generate excessive correspondence, meetings, delays, claims, or lawsuits.

Conclusions

It is difficult to establish standard specifications for use in the construction industry. Despite advances, more effort is needed to shift preferences towards employing scheduling technology. Scheduling software aids in the effective daily decision-making on projects, predicting time problems encountered when altering the scope of work. No single industry scheduling procedure is applicable for all projects, however, the procedure for reaching timely scheduling decisions should be established prior to its demand. Contractor preferences for updating, cost loading, and formatted reports effect the success of the project. Specifications for these scheduling issues should be agreed upon by all parties prior to construction and included in the contract's supplemental conditions.

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