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Educational Practice Manuscripts

Educational Research Manuscripts

General Manuscripts

Other

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Spring 1997, Vol. 2, No. 1, pp. 6-12

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Automatic Data Collection Technologies in a Construction Curriculum

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The construction industry is a data-driven service industry. Studies indicate that 80 percent of the information collected by a department (division or office) must be shared with others. The Department of Building Construction and Contracting (BC) at Purdue University embraces the philosophy of teaching students to manage the process of construction through the utilization of technological and data management skills derived from academic learning and field application experience. Gaining experience in the application of the new technologies of Automatic Data Collection (ADC) is one method available for students to become key elements in assisting companies to adopt and effectively utilize them. Therefore, the department began the process of implementing ADC technologies into the curriculum through a process of grant application and award (The 1995 Zinger Award). Survey results from the grant indicated 0.8 percent of the companies surveyed used bar coding, and that a large 69 percent knew little or nothing about bar coding and ADC. However, 43 percent indicated they would like to know more. Included is a discussion of what ADC technologies are, how ADC is being implemented into the BC program, and the expected outcomes.

Key Words: Bar Coding, Tool Tracking, Automatic Data Collection, Keyless Entry, Construction Curriculum

Introduction

Construction is an intensive data (information) driven service industry. The entire process of estimating, scheduling, planning, tracking, document control, construction, management, and supervision of a construction project is simply the accurate and timely gathering and sharing of information with others. Studies indicate that 80 percent of the information collected by a department (division or office) must be shared with others. Those companies who manage their data gathering and dissemination processes best generally yield the best profits. How profitable are companies with good data gathering and dissemination skills? On the average, their yield is one-and-one-half to three percent net margin (CFMA, 1995). Notice two things about such a low margin. First, it doesn't take much of a loss to place the company into a negative position. Second, it doesn't take much of a productivity gain to increase or double the margin. Since the industry is so intensively data driven, and the primary productivity problems (lack of materials, lack of tools, lack of instructions, and rework) are management problems, it appears management is having a data breakdown (Construction Labor Motivation, 1982).

Why do we have such problems with the collection and distribution of data? A primary reason is the human factor. Human data entry, whether written or keyboarded, is inherently error prone. Studies show that humans performing manual data collection and manual data entry tend to have one error in every three hundred characters entered (AlMusa, 1994). Applying Automatic Data Collection (ADC) technologies to data collection and data entry tasks will eliminate these two error-prone and time-consuming activities, and pose an error rate of one in one to three million characters (D. Dunlap, 1995). As a result, ADC technologies allow management to run the business, instead of allowing business to run the management.

The Department of Building Construction and Contracting teaches individuals how to manage the construction process. The department's philosophy is to be on the leading edge of applied construction technology. Currently the department is completing the first year of a two-year grant to implement bar coding into the construction curriculum. The Field Engineering (surveying) Lab was the first area in the curriculum to adopt bar coding for the purpose of tracking equipment, job locations, preparing equipment status and maintenance reports, and to record time and attendance of students.

The department has a two-fold purpose in the utilization of bar coding. The first is to expose the students (future constructors) to the use of bar coding by having them check equipment in and out to various field lab locations representing job sites. The second purpose is to actually instruct them in the process of designing and implementing a bar code application to solve a specifically perceived company need. The goal here is to have students graduating who are familiar with bar code technology and unafraid to apply it in an industry setting.

ADC Technologies

ADC is a family of technologies that can place accurate and timely data at the fingertips of faculty, staff, students, management, and labor. ADC is an acronym used to describe direct entry of data into a computer system, or other medium, without using a keyboard. According to ALMUSA (1994), ADC technologies roughly fall into six categories: optical, magnetic, electromagnetic, biometric, touch based, and smart card.

These technological tools automate the repetitive information demands of modern business. The successful application of ADC technologies requires a careful study of the work process that is being considered for adaptation. A process study of the Field Engineering Lab was done and revised several times to determine the best adaptation of bar coding to the everyday functions of checking equipment in and out for lab exercises. Careful process study provides clearer understanding of laboratory management practices, allowing faculty and staff to improve them. Management practices can be improved by ADC in three specific ways:

1. Data entry is streamlined, automated, and inexpensive
2. Accuracy, speed, and reliability are the underlying reasons for implementing an automatic data collection system
3. Programs or companies incorporating ADC into their educational or work structure acquire measurable returns through the improved efficiency of existing processes (D. Dunlap, 1995)

Accurate information in meaningful detail allows faculty, staff, students, management, and labor to track equipment in batch or real time, and therefore, know how the equipment in the labs and field operations are performing. One can choose the initial ADC tool from among the following ADC Technologies.

- Optical: Bar coding (includes two dimensional symbologies); Optical character recognition (OCR); Vision systems; Mark sense; and some Biometrics Magnetic: Magnetic stripe
- Magnetic ink character recognition (MICR)
- Elemmagnetic: Radio frequency identification (RFlD); and Radio frequency data communication (RFDC)
- Biometric: Voice recognition systems Touch: Touch screens; Button memory
- Smart Card: Card-based storage/retrieval device

Discussed further are the various types of ADC technologies:

Optical type of ADC Technology Bar Codes

Bar coding has been accepted and applied in a wide variety of industries. Of all of the ADC technologies, bar coding probably has the broadest potential for application. What is a bar code? Printed bar codes, called symbols (or symbology), are typically a series of alternating light and dark "bars" which are produced according to published specifications. Bar codes are inexpensive to produce, and are therefore disposable, highly accurate, and tolerant of moderate amounts of damage. They can be optically read by a wide range of scanning methods (AIM^{usa}, 1994).

At last count, there were approximately225 known bar code symbologies. Only a few are widely used. Traditional bar codes are linear (one dimensional). Popular in industrial, medical, and government applications is Code 39, an alphanumeric symbology with self-checking properties that offers a variable length and a high degree of data security. This seems to be the symbol of choice for construction, and is what we are using at Purdue. Bar code applications appear unlimited. It is an extremely effective identification tool that provides accurate and timely support of the data requirements for sophisticated management systems. Bar code usage generally increases accuracy and productivity, creates cost saving, and improves business operations (AIXTOMATIC ID NEWS, 1995-96).

Bar Code Scanners

The scanner actually reads the bar code symbol. Scanners can be broken into two main categories: Contact and Non-contact. Contact scanners must touch or come into close proximity to the bar code symbol. Wands are examples of this type of scanner. Non-contact scanners do not have to be in close proximity to the bar code symbol in order to read it (AIM^{usa}, 1994).

Optical Cards

Optical cards are credit-card-size plastic cards. Data is stored on a plurality of tracks that can be read optically. Though these cards can store a great amount of data in a very small space, the data is not easily updated or changed (ADI[usa], 1994).

Magnetic type of ADC Technology Magnetic Stripe

Magnetic stripe technology uses the magnetic field of an encoding head to record data in the form of magnetic flux reversals. The best-known applications are on credit and debit cards for use in automatic teller machines (ATMs) and point-of-sale (POS) terminal (AIM[usa], 1994). The Electromagnetic type of ADC Technology RF Data Communications (RF/DC) is an exciting technology for the construction industry. In the material-handling industry, RF/DC allows shipping, receiving, storage, retrieval, order picking pick-slot replenishment, real-time information gathering, and other instructions to be transmitted directly to and from terminal operators and the host computer (AIMED, 1994).

Radio Frequency Identification (RF/ID)

Radio frequency identification (RF/ID) is basically an electronic form of bar coding where electronic labels (or "tags") are programmed with unique information and attached to objects that need to be identified or tracked, such as pallets, vehicles, automated guided vehicles, etc. Read ranges from less than 1 inch to 100 feet or more are useful in rugged industrial environments where other contact or near-contact ID readers would be damaged or misaligned during operations (AIMusa, 1994).

Smart Card type of ADC Technology Smart Cards

The smart card is a method of Automatic ID that uses a credit-card-size plastic card with one or more microchips embedded in it. The term "smart card" is also applied to plastic cards that only contain memory and are used for applications such as coin replacement or units of inventory. Contact less smart cards are read and are written | to remotely by radio frequency signals for toll collection, container contents, and vehicle identification (AIM[usa], 1994).

Touch type of ADC Technology Memory Buttons

The memory data container is an electronic identification device accessed when touched with an E metal probe or wand that reads the data on the memory chip. Memory buttons are often used in harsh environments where contact reading is acceptable or desired (AIM[usa], 1994). Biometric type of ADC Technology Voice Input/Output Voice recognition technology converts sounds, l words, or phrases spoken by humans into electrical signals and transforms these signals into coding patterns with l assigned meanings. Voice recognition is ideal where speed, accuracy and real-time data are a requirement. Biometric ADC Technology is most beneficial when an operator's hands or eyes are occupied in activities such as in laboratory work, bridge inspection, inventory control, forklift operations, and especially in quality control for automotive manufacturing (AIM[usa], 1994).

EDI

Electronic data interchange (EDI) is the application-to-application electronic exchange of business data found in invoices, purchase orders, and dozens of other business transactions. EDI reduces lead times and inventory levels, improves bi-directional information accuracy, reduces management costs, and improves the quality of products and services (AIM^{usa}, 1994).

Drafting the Klinger Award Proposal

The characteristics of ADC briefly discussed above have primarily been adapted, tested, and proven in industries other than construction and education. The Department of Building Construction and Contracting (BC) agreed that the ADC technologies were sufficiently powerful, developed (user friendly), inexpensive, and cost effective (ROI) that it was highly probable that the construction industry is on the verge of adopting many of them in the near future (three to five years). With this in mind, the 1995 AGC Klinger Award Proposal to bar code the curriculum was drafted.

The primary concept of the Klinger Proposal was to implement first the most cost effective, applicable technology into our curriculum. Through phone interviews and personal interviews, the department became acutely aware that the initial application of ADC technologies in the construction industry has been primarily bar coding used for tool tracking. The department also discovered that bar coding was the simplest and least expensive application of the ADC technologies. The Klinger Award was received, and implementation of bar coding into the curriculum was initiated.

Implementing a Bar Code Plan into a Construction Curriculum

A committee was formed to work on the implementation of bar coding into the curriculum. A questionnaire was developed to ascertain knowledge of the use of bar coding in the construction industry. The questionnaires were mailed to 1000 randomly selected AGC contractors, 600 top mechanical, and 400 top electrical contractors in the US. In addition, a phone interview questionnaire was prepared and a list of bar code users was developed through referrals. The committee visited the sites of several types of businesses that are bar code users to personally view how their systems functioned. Sites visited were:

- The Purdue University Tool Crib, Purdue University, W. Lafayette IN
- Landis and Gyr (manufacturer of electrical meters), Lafayette, IN
- The Caterpillar Engine Facility, Lafayette, IN

Furthermore, the committee attended seminars and institutes, and read about and compared a half dozen off-the shelf software and hardware packages that would track tools. The committee also considered semi-custom software and full custom applications. After all of this, it was decided to use an off-the-shelf tool-tracking program. After careful study and many live interviews with bar code users, a vendor, Tool Watch, Inc., was contacted and the department' s position was described. The vendor asked for a proposal. In order to develop the proposal for Tool Watch, the department committee had to study the applications (processes) in our curriculum that were most likely suited to bar code adaptation. A proposal was prepared based on identified needs and capabilities. ToolWatch, Inc., accepted the proposal and sent all of the hardware and software needed to set up two labs with tool and equipment control bar code systems.

Results

Results from the survey from the grant indicated that 0.8 percent of the companies surveyed used bar coding, and that a large 69 percent knew little or nothing about bar coding and ADC. However, 43 percent indicated they would like to know more.

Implementation of bar coding began in the Field Engineering Lab. Equipment and field books are controlled as well as time and attendance. The department committee, along with the responsible faculty and lab coordinator, were charged with the development of the goals and objectives of bar code application in the Field Engineering Lab.

The second lab to be brought on line as an actual Tool Crib operation is the Construction Lab. Data bases are being created toward that end.

A third lab, the Field Operations Lab. (FOL), is an office being established on the mezzanine of the Construction Lab. This office replicates the functions of a superintendent's trailer on the job site. From the FOL, the juniors will be supervising the freshmen as they are building structures in the Construction Lab. The juniors collect and report data using bar codes and scanners; they gather data concerning inventory, productivity, tool control, and safety. This information is loaded onto the job site computer (in the FOL) and sent to the Project Management Office Lab on the 4th floor, where the seniors can use the information to determine productivity, adjust schedules, and receive field orders.

The above application of bar coding is one way that students are provided the opportunity to use an ADC technology and learn what it can do. A second step is to actually show them how to develop and implement a bar code system. One of the most interesting aspects is the requirement that in order to develop and implement a bar code system, it is necessary to break down the information and work process to study them in detail (D. Dunlap, 1995). This seemingly small step is of major importance to the success of using ADC technologies. It is also an important step in analyzing and managing a company or a project. With this in mind, Dr. Fritz Muehlhausen is preparing a block of lectures and hands-on exercises where juniors in the site-planning course will develop a bar coding system for a company. Completing this course will prepare the students for the opportunity to apply their knowledge in the field in as early as the summer between their junior and senior years.

Conclusion

There is not a single best ADC technology. The application and surrounding conditions will determine which ADC technology best suits a curriculum or a company's needs. Since 1990, the ADC industry has been one of the fastest growing segments of the information collection technology market. Study evidence indicates that 80 percent of the information collected in a department must be shared with others (D. Dunlap, 1995). Therefore, the question should be, "How important is timely, accurate, and reliable data collection?" If making precise business decisions based on collected data is important, how can you not use an ADC technology? Can a company or an institution afford not to? The future of ADC applications in the construction industry and in the academic community will only be limited by a lack of imagination and an unwillingness to embrace these new data collection technologies. Cost will not be the deterrent, user friendliness will not be the deterrent, only industry's refusal to change will keep the construction industry from utilizing ADC technologies. However, the saving grace will probably be, that if the competition effectively uses a new technology, other companies will be forced to use it in order to compete (D. J. Collins, 1994). The bottom line is that graduates exposed to new technologies in their undergraduate curriculum may very well become the change agents of the construction industry. Similar to what is now occurring with the utilization of computers in construction, once basis foundation of a new technology is financially successful industry or academia. The users will become very creative in the application of ADC technologies. This is only the beginning.

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Incorporating Reserve Fund Analysis into Graduate Construction Education

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A central theme of this paper is that construction management graduates posses the necessary knowledge and skills to participate more fully in the development process, and specifically in the post development property management function of reserve fund analyses. Four areas are briefly examined: 1) the real estate development process with specific interest in the post-development stage; 2) the unique characteristics of real estate and particularly as they relate to professional service opportunities; 3) the construction/project management objective's of a quality product, produced on time and within budget, and specifically the techniques of scheduling, estimating and contract administration which support these objectives; and 4) reserve fund analysis fundamentals. This information is synthesized to establish a logical link between the inherent characteristics of real estate during post-development property management, on-going management of the asset, and project management tools and techniques typified by graduate programs in construction science. Based on establishment of this link, the question of supply and demand for reserve fund analysis services is addressed. Trends related to construction value and laws related to association boards' fiduciary responsibility are presented as operationalization of the demand construct. The supply construct is operationalized as availability of specific reserve fund analysis courses and/or concentrations in facilities management in graduate construction programs.

Key Words: Reserve Fund, Replacement Fund, Construction Management, and Construction Graduate Education

Introduction

As educators of future professionals of the built environment, at least one of our primary objectives should be to develop knowledge and skills that are needed by society. In construction related programs, and especially at the graduate level, this often includes advanced training in the management aspects. Unfortunately, we tend to look rather narrowly at the potential "management" market the construction graduate student will enter. Construction is but one phase, and actually a rather short one in the life of real property. The majority of time is spent in managing the property once it has been built. Management of property, specifically the operational aspects, are perhaps best filled by individuals with training more directly focused in this area. However, continued management of the physical aspects of the property require knowledge and experience in construction related areas such as contract bidding and administration; estimating and scheduling; and materials and methods. This knowledge alone, however, does not qualify a property or construction manager to compute and evaluate reserve fund analyses. Producing quality reserve fund analysis requires additional knowledge and training in this area.

The purpose of this paper is to establish a logical link between the inherent characteristics of real estate during post-development property management, on-going management of the asset, and project management tools and techniques typified by graduate programs in construction science. In order to more fully understand this logical link, a brief explanation will be provided for the real estate development process, including some of the unique characteristics that complicate as well as provide opportunity for professional services. Included also are the objectives and tools typified by professional construction/project management, especially as typified by graduate programs in this area, and the basic steps of a reserve fund analysis. Following these examinations, the paper will focus on the questions of supply and demand for services in this area.

The Real Estate Development Process

This section will provide an overview of the development process to establish the context, including sequencing and duration, as well as typical participants, in which property reserve fund analysis is conducted. According to Blew (I 989) real estate development is "... the steps by which a property may be altered over time to increase it's value or usefulness". The steps that Blew refers to vary in number and exact sequence depending on the scope and nature of the project, but in general follow four stages (Sharkawy, 1994) as shown in Appendix A, diagrammed by Sharkawy and Nobe (I 995):

Pre-Development.

This stage begins with conception of the project. As project inception activities progress, the developer will begin to solicit financial interest both from equity investors and lending institutions. At the conclusion of this stage, the market has been preliminarily analyzed; highest and best use identified; conceptual design completed; and conceptual estimates, schedules and proformas completed.

Document Development.

During this stage preliminary studies are completed, estimates and schedules refined, and letters of commitment are sought both from construction and permanent lenders. Given a financial commitment, final working drawings, specifications, budgets, contracts, and financial statements are prepared. Final approvals from various regulatory agencies are sought and received and during this time bidding and/or negotiation of the various portions of the work can be completed.

Product Development.

Upon completion of the final working drawings (except in the case of fast track projects), the project enters the project production or construction phase. Beginning with the closing of the construction loan and signing of construction related contracts, mobilization and construction proceed. Marketing, leasing, and/or pre-sales activities will commence at some point during this phase, if not earlier. Upon completion of construction and fulfillment of the terms of the permanent loan covenants, the construction lender is *taken out* (refinanced) by the permanent lender.

Post Development.

This stage will vary by type of development (i.e. residential, commercial, mixed use, etc.) but may include continuation of sales, leasing, or a combination of both. In general, this stage is known as *Property Management* but will also include Asset Management. In both cases, the prime objective is management of the physical and financial assets with the intent of minimizing the risks and optimizing the long-term cash flow and associated value of the property.

The development sub-stages, particularly construction/rehabilitation and property management are not drawn to time-scale in Appendix A, and therefore under represents the magnitude of post development and the associated property management function. It does nevertheless depict the overall context in which construction mangers participate. Specifically, construction is shown as one of many phases, and in the overall life of the asset, a relatively short one. Also shown is the large number of typical participants in the development process. Similarly to duration of construction, the construction managers' role is typically limited in scope as well.

Unique Characteristics of Real Estate

Etter (1989) provides a useful summarization of three unique characteristics of real estate which complicate investment decisions:

Physical immobility.

Real estate cannot be easily relocated at some future date, and therefore, its value is directly related to the market area in which it is constructed.

Long economic life.

It takes many years, often decades, to recover the cost of the asset through it's ability to generate income.

Large economic outlay.

Cost of acquisition and/or construction is large, often requiring the use of long-term financing in addition to investor equity.

In addition to complication of initial investment decisions during the pre-development stage, it is these very characteristics, the essence of real estate, which require the continued management of the asset for the duration of the holding period. Further, it is these characteristics and their associated need to be managed which provide the basis of demand for property management, including the analysis of reserve funds. Therefore, within the unique characteristics that complicate real estate investment initially lays the opportunity for continued management.

Construction and Project Management

Consistent with research by Berryman, Jensen and Craig (1995) and definitions developed by the Project Management Institute, as well as other respected experts in the field of construction/project management (Clough and Sears, 1979, Barrie and Paulson, Jr. 1978), the following primary objectives are suggested:

Quality.

Conformance to project requirements and/or specifications, which may include elements in alignment with the economic, social, political, legal and environmental, desires of all interested and influential parties to the project.

Time.

This objective encompasses the four areas of planning, estimating, scheduling and control. Planning includes defining the project/owner's goals and objectives; preparation of strategies to accomplish the stated goals and objectives; and identification of specific methods which may be employed.

Cost.

This includes all processes that are employed to maintain financial control over the project, generally classified as estimating and cost control (which include forecasting, estimating, budgeting, monitoring and reporting). Also included in these areas is the estimation of life cycle costs.

Further building on the central theme of Berryman, et. al. project management is recognized as the core discipline of construction management. Therefore, for purposes of this paper, the underlying management principles and techniques that are utilized in construction and project management are considered synonymous. The project manager utilizes many tools to meet the objectives stated earlier. Several, which are among the core curriculum of most construction management programs, are:

- Contract Administration
- Scheduling
- Estimating
- Materials and Methods

As Wyndhamsmith (1986) suggests "... selection of a Reserve Study Specialists should center on the consultant's past experience and knowledge of construction (structural, mechanical, electrical and landscape infrastructures) or the ability to put these skills into an understandable document." (Author highlight). The authors suggest that graduate students, properly equipped with construction knowledge, project management tools, and given a basic understanding of reserve fund analysis, are well suited for this service.

Reserve Fund Analysis

"Reserves for Replacement, are estimates of that amount of money which must be put aside to replace major items (or building components) that will wear out before the entire facility or project wears out... " (Wyndhamsmith 1986). Common industry terminology also includes Reserve Fund, Maintenance Reserve, Replacement Fund, Replacement Plan, Capital Replacement and/or any combination of the above. Two recent observations help establish the importance of reserve funds. "Establishing a reserve fund for your condominium association is a little like flossing: You don't have to do it for all your associations, just the ones you want to keep" (Anderson, 1994). "One area that seldom has a well developed plan of action is the replacement of the physical assets of a property" (Moseman, 1995).

Replacement funds can range from the polar extremes of "pay as you go" to "special assess as you need". Without going into the philosophical underpinnings of these extremes and the impact this has on the overall format of the fund, the generic step process of establishing and administering a replacement fund can be summarized as follows:

- Prepare list of capital items
- Determine quantity of items
- Determine quality of items
- Determine useful life
- Determine current cost
- Establish Board of Directors risk level
- Determine inflation and interest rates trends
- Determine existing fund
- Determine needed fund
- Determine contribution/special assessment requirements
- Prepare short term bid packages
- Administer contract

Based on historical association documents; a physical property survey; and interviews of property managers, tenants and board members, information is compiled, analyzed and used to generate a replacement fund. A sample fund is shown below in Table 1.

The process outlined above and the core curriculum discussed earlier suggests a logical link between current educational skills development and required functional responsibility of reserve fund management. If the premise that construction mangers are fundamentally equipped to produce reserve fund analyses is accepted, two additional questions must be answered. First, is there a sustainable demand for these types of services, and second, do graduates in construction have access to courses geared specifically toward reserve fund analysis. These two questions are addressed in the following sections.

The Demand for Reserve Fund Analysis

Socially, it comes as no surprise that people of this nation are individually concerned and collectively committed to demanding greater fiscal responsibility from their elected officials. The national debt and budget deficit debates stand as evidence as to the status to which this issue has been elevated. Similarly, individual homeowners have recently begun to demand the same type of fiscal responsibility from their elected board of directors. A recent article in the

Table 1

Sample Reserve Fund Analysis

XYZ ASSOCIATION, INC.
REPLACEMENT FUND EXPENDITURE & ASSESSMENT ANALYSIS: 1995-2010

1995 ASSESSMENT:	**300,000**
YEARLY ASSETS INCR:	**3.0%**
RATE OF INFLATION	**5.0%**
RATE OF INTEREST:	**8.0%**

Bldg.	Item NO.	Description	Avg. Life	1995 Age	1995 Cost	Req'd Bal.	1996 Expense	1996 Contrib.	1996 Expense	1996 Contrib.	1997 Expense	1997 Contrib.	1998 Expense	1998 Contrib.	1999 Expense	1999 Contrib.	2000 Expense	2000 Contrib.
I	1	Roofing	18	14	92,000	77,905		7,870		8,264		8,677		9,111	(111,827)	9,566		10,045
	2	Exterior Painting	5	1	15,654	3,444		3,616		3,796		3,986		4,186	(19,028)	4,395		4,615
	3	Signage	12	9	3,000	2,406		338		355		373	(3,473)	392		411		432
	4	Interior Painting	7	5	4,600	3,442		795		835	(5,072)	876		920		966		1,015
	5	Carpet	10	8	3,800	3,181		492		517	(4,190)	543		570		598		628
I I	6	Roofing	18	10	98,000	64,735		8,384		8,803		9,243		9,705		10,190		10,700
	7	Exterior Painting	6	2	20,200	7,400		3,980		4,179		4,388		4,607	(24,553)	4,837		5,079
	8	Signage	10	3	4,700	1,658		609		639		671		705		740		777
	9	Interior Painting	7	5	3,600	2,694		622		653	(3,969)	686		720		756		794
	10	Carpet	3	5	5,000	3,349		774		812		853	(5,788)	896		940		987
Pool Bldg.	11	Roofing	16	10	43,000	30,637		3,968		4,166		4,374		4,593		4,823		5,064
	12	Exterior Painting	6	2	13,900	5,892		2,739		2,875		3,019		3,170	(16,896)	3,329		3,495
	13	Signage	5	1	5,000	1,100		1,155		1,213		1,273		1,337	(6,078)	1,404		1,474
	14	Plaster	15	11	87,000	69,623		8,382		8,801		9,241		9,703	(105,749)	10,188		10,698
	15	Furniture	4	2	4,000	2,098		1,128		1,184	(4,410)	1,244		1,306		1,371		1,440
	16	Mechanical	12	11	68,000	63,728		7,672	(74,970)	8,056		8,459		8,881		9,326		9,792
	17	Air Handling System	15	10	15,000	1,159		1,445		1,517		1,593		1,673		1,575	(19,144)	1,844
	18	Concrete Covering	10	1	5,400	666		699		734		771		810		850		893
Other	19	Pathways	4	2	1,000	524		282			(1,103)	311		326		343		360
	20	Parking Lot Patching	3	2	2,000	1,366		734	(2,205)	771		810		850	(2,431)	893		937
	21	Landscaping	1	1	1,000	1,000		1,050	(1,103)	1,103	(1,103)	1,158	(1,158)	1,216	(1,276)	1,276	(1,276)	1,340
	22	Resurface	10	9	31,000	28,535		4,015	(34,178)	4,215		4,426		4,647		4,880		5,124
	23	Elevator	15	14	35,000	33,378		3,372	(38,588)									
	24	Window	15	12	59,000	50,380		5,684	(1,380)									
	25	Common Doors	10	6	9,800	6,442		1,269		1,333		1,399		1,469	(11,912)	1,543		1,620
	26	Miscellaneous	1	1	2,000	2,000	8,110	2,100	(2,205)	2,205	(2,205)	2,315	(2,315)	2,431	(2,431)	2,533	(2,553)	1,680
		Previous Year End Balance						477,940		540,903		452,773		499,097		489,855		263,118
		Current Year Assessments						71,073		65,118		68,374		71,792		75,382		79,151
		Current Year Expense					(8,110)		(153,248)		(22,050)		(81,034)		(302,119)		(22,973)	
		Current year-end Balance				477,948		540.903		452,773		499,097		489,855		263,118		319,296
		Previous Year End Balance						188,475		484,230		678,821		499,097		1,376,953		1,511,980
		Current Year Assessments						300,000		309,000		318,270		71,792		337,653		347,782
		Interest						8,865		38,839		65,272		89,855		99,493		133,032
		Current Year Expense					(8,110)		(153,248)		(22,050)		(81,034)		(302,119)		(22,973)	
		Current year-end Balance				182,475		484,230		678,821		1,040,314		1,376,953		1,511,980		1,969,821
		Excess (Shortfall)				289,465		(56,673)		226,048		541,217		887,098		1,248,862		1,650,525

Journal of Property Management which is based on several interviews with experts in this area (Anderson, 1994) supports this view:

- *Buyers are putting clauses into their purchase agreements that make the sale of the unit dependent on the existence of healthy reserves* (Maureen Reardon, CPM, President, Progressive Management, Inc., Florida)

- *Buyers are becoming much more sophisticated. If they see an association is under funded, they are likely to go somewhere else* (R. Donald Larrance, CPM, President, Perry & Co., Colorado)

- *I think we are dealing with much more knowledgeable, and more sophisticated people than we were before... Condo associations now want more in-depth analysis of reserves* (Roger Kramer, CPK President and owner, Kramer and Associates, Ltd., Michigan)

This public demand has resulted in higher standards in both the legal and accounting professions, and in some states even in the enactment of laws requiring the use of reserve fund analysis. In California for example, since 1992 associations have been required to complete studies of their reserves every three years. Regardless of whether laws have been enacted or not, the lawyers and accountants have responded by raising their professional standards when it comes to assessment of reserves. As Anderson (I 994) notes "... the accounting industry's disclosure requirements have become more stringent, and CAI predicts this trend will continue ... Since 1991 the American Institute of Certified Public Accountants has required auditors review ... the basis for establishing reserves." It stands to reason that as one profession responds to the new standard, so to will others, especially financial institutions that provide capital to purchase such property.

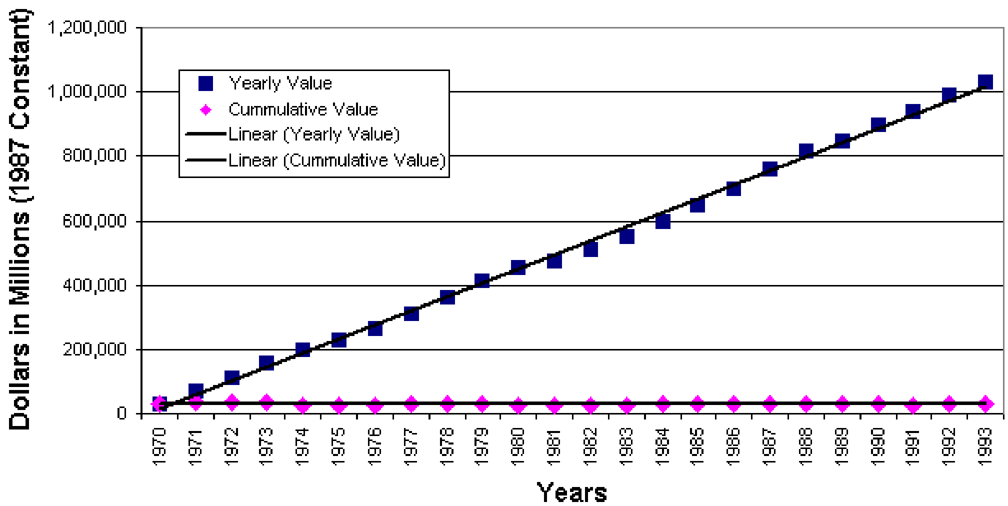

Figure 1: Dollar Value of Multi-Family Residential Construction

From a physical perspective, demand is logically tied to the amount of real estate that exists. This would include not only new construction, and especially new residential multi-family construction, but also all construction which has been put in place over the last several decades and which has not yet reached its useful life. Review of the data indicates a substantial and growing market. Between 1970 and 1990, the value of residential capital stock in this country has increased by 75% (in constant dollars), due in part by the nearly 50% increase in multi-family housing units over this same period. Perhaps more telling, since capital stock numbers are distilled components of gross national product, is the cumulative value of new multi-family residential construction put in place. Figure 1 shows both yearly and cumulative estimated values of private multifamily residential construction put in place. Although the trend in constant dollars has remained rather flat, it is the cumulative value, and associated market, which should be noted as a growing and substantial potential market. This follows the earlier discussion of unique characteristics of real estate (which are typically thought to complicate real estate investment decisions), and especially the concepts of physical immobility and long economic life. The point is that real estate lasts a long time and during that time frame, the physical aspects of the project must be managed. The need for this service is an opportunity for anyone possessing the proper knowledge and technical training.

Supply Assessment

Although it is recognized that there are a multitude of potential participants in the analysis and management of reserve funds, (i.e. lawyers, accountants, engineers), in most cases work by these individuals will be limited to select input into a comprehensive model. Generally management of the overall process is left to someone else. The current champion of the process is the property manger, who in many instances would rather manage a professional consultant that the process itself As it has been contended, graduate students from construction related programs are well suited for management of this process, given the proper technical skills associated with reserve analysis. Do graduate construction students have access to this type of technical training? To address this question, a survey of graduate construction programs across the United States was conducted. The target population was all graduate programs in construction. The sample population was all institutional members of the Associated Schools of Construction (ASC). Although underrepresented, the strong membership of the ASC can be considered a provider of good external validity for the survey results.

There are 84 institutions within the ASC membership. Of the 54 ASC members that were polled, 26 sent back responses. With a 95% confidence level, the sampling error was ± 7.7%. The respondents of the sample were evenly dispersed geographically across the United States which allowed the following sample inferences to be made of the ASC population (84 colleges) as a whole: 46% percent of the ASC colleges teach some or all aspects of facilities management and 27% of these same colleges teach reserve fund analysis (see Exhibit 1.3 for summary data). Further statistical evaluation, using binomial probability distribution, imply that there is a very low (12.6%) probability that a random sample of 23 colleges (27% of all ASC members) from the 84 ASC members list would teach reserve fund analysis. These indicators infer that there is a small group of colleges training graduate students in reserve fund analysis. Given these results and the relatively small number of graduate students completing college (in comparison to undergraduates), it can be concluded that there are few construction graduates being trained in reserve fund analysis.

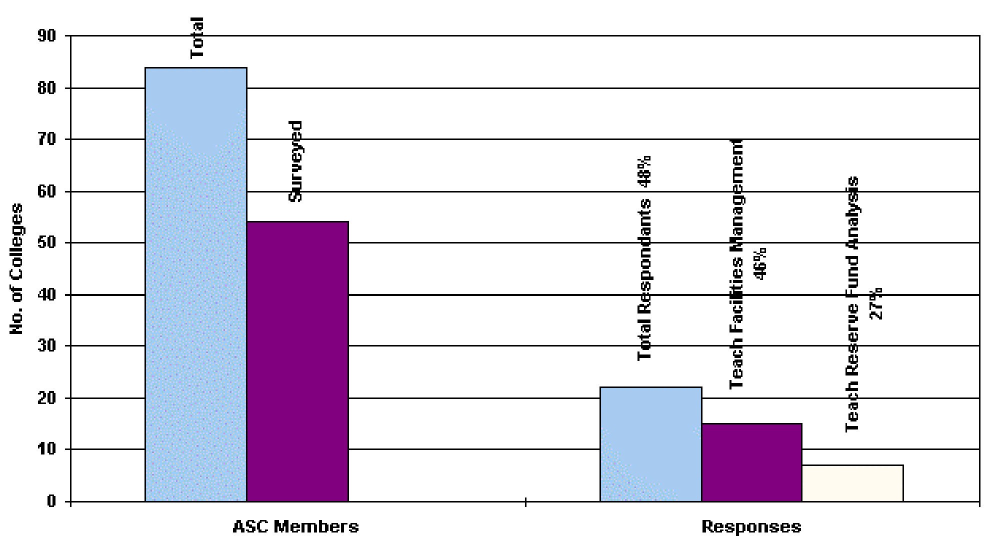

Figure 2: ASC Survey Results Facilities Management and Reserve Fund Analysis

Conclusion

This intent of this study was to establish a broad understanding of the real estate development process and the unique characteristics commonly associated with investment in this area. In addition, the fundamentals of construction/project management and reserve fund analysis/management were developed. From this broad-brush perspective, several primary points were established. First, real estate development is a long process with the majority of time being consumed by on-going management of the property. Owing to it's unique characteristics, primarily physical immobility and long economic life, which typically are considered risk factors to the investor, there is a virtually continuous opportunity for service. Cumulative trends of real estate in place support this supposition. The requirements of reserve fund analysis and the core curriculum of graduate construction education are closely aligned. This evidence suggests that there is demand for professionals trained in construction to produce reserve fund analyses. Unfortunately, very few schools appear to currently be offering either a course or concentration in either facilities management and/or reserve fund analysis.

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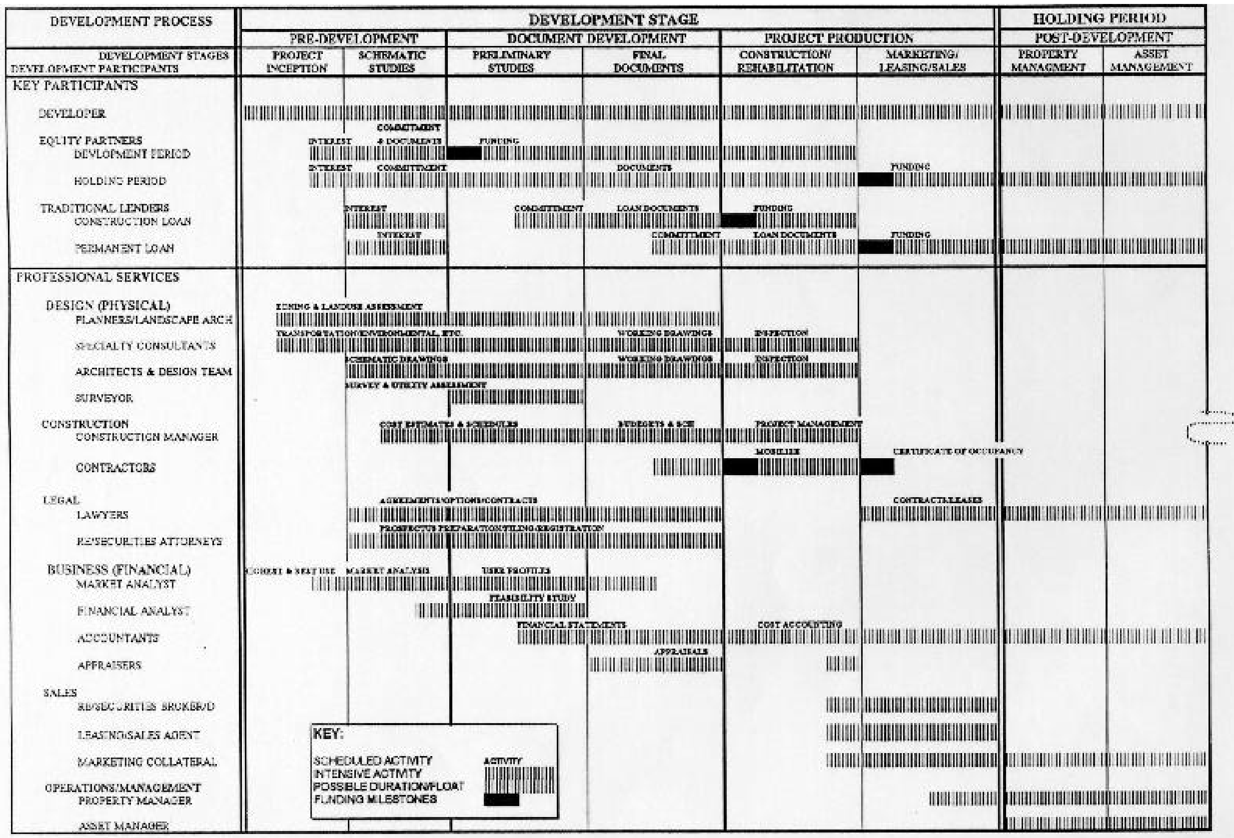
Appendix A
The Property Development Process



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Desirable Characteristics of the Professional Constructor: The Results of the Constructor Certification Skills and Knowledge Survey

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The purpose of this paper is to identify those skills and knowledge that are vital to professional constructors. This was accomplished by means of a statistical review of the Constructor Certification Skills and Knowledge Survey, which was developed by the American Institute of Constructors and the Constructor Certification Commission. Research objectives were as follows: to identify whether the ten Duties outlined in the AIC Constructor Certification Skills and Knowledge Survey are important to professional constructors; and to identify which of the ten Duties are *most* important. Findings indicate that the array of skills and knowledge outlined on the survey are very comprehensive, and that the ten Duties are indeed important to professional constructors. Further, three particular Duties--problem solving, estimating/budgeting, and project management--were found to be the *most* important of all Duties outlined on the survey.

Key Words: American Institute of Constructors, Constructor Certification Commission, Constructor Certification Skills and Knowledge Survey, Professional Certification, Management Characteristics

Introduction

In recent decades, the construction industry has been impacted by constant, and often radical, changes. Rapidly advancing technologies, new forms of contractual relationships, and new methods of project delivery have all served to make construction projects more complex. Additionally, the industry is experiencing such trends as severe shortages in the availability of skilled labor, increases in claims and litigation, and increased competition from international and foreign organizations. At the same time, profit margins and return on investment are minimal. All of this is occurring in an environment where the image of the construction industry and its workers is on the decline.

The industry is highly resource intensive. Effective utilization of labor, material, and equipment are key to the entire construction process. Above all else, a capable management team--with the requisite skills and knowledge--is needed for successful performance and delivery of projects.

Considering this, one might be inclined to ask, what are these "requisite skills and knowledge"? What abilities are required of administrative and management level employees in the construction industry? Helping to address these questions is the purpose of the research reported here.

For nearly 25 years, the American Institute of Constructors (AIC) has promoted the management of the construction process as a professional discipline that complements the design professions of architecture and engineering. In 1993, along with ten other trade and professional associations, the AIC helped to form the Constructor Certification Commission (CCC) with the expressed purpose of developing and administering a valid set of professional certification examinations for professional constructors. Certification of practitioners--along with an identifiable body of knowledge, a code of professional ethics, and a learned society--are considered to be the central tenants of professionalism in any discipline.

How, then, might one go about identifying those skills and knowledge which professional constructors use to perform their work? This was the dilemma faced by the CCC at the start of the certification effort. To help address this question, a comprehensive survey instrument was developed and administered by the Commission. This survey was designed to measure the perception of practitioners relative to an extensive list of abilities that might be required of constructors. During the past year, over 200 respondents have completed this instrument.

Beyond the completion of the survey instrument, progress continues on other steps necessary to complete the examinations. At this point, the examination specifications have been written and are now being revised. Plans are in place for a two level exam with Level 1 designed for recent college graduates and Level 2 for practicing professionals with at least seven years experience. The test items for both sets of examinations are presently being written, with the first round of testing scheduled for November 1996. Proposals for pilot testing of early forms of the examinations are now being considered to ensure validity and consistency of the test items.

The purpose of paper is to report on the results of the comprehensive "Skills and Knowledge Survey" as tabulated by the authors at Colorado State University.

Research Objectives

Based upon the format of this survey instrument, the following research questions were developed:

1. Are the ten "DUTIES" outlined in the AIC Constructor Certification Skills and Knowledge Survey (see Appendix A) perceived as being important to construction professionals?
2. Which of these ten "DUTIES" are perceived to be the most important?

Procedures And Methodology

Instrument Development and Subject Selection

Development of the "Skills and Knowledge Survey" was performed by the American Institute of Constructors and the Constructor Certification Commission. Its form was adapted from surveys developed by the Chartered Institute of Building in London which certifies managers of construction internationally wherever the British or European system of contracts are used.

The purpose of the survey was to measure the relative importance of ten sets of "Duties" or responsibilities performed by professional managers of the construction process. These ten Duties were comprised of 39 tasks that encompassed a comprehensive list of 257 Performance Criteria or individual skills of the discipline. (See Appendix A for an outline of the survey structure.)

Surveys were distributed to a broad cross-section of construction professionals. Effort was made to distribute the survey nationally. This paper and its findings represent an analysis of the survey data obtained from a usable pool of 206 respondents.

Demographics

The distribution of respondents is shown in Figure 1a &1b. In total, 36 states were represented, with 15 respondents not indicating their state of residence. Respondents were asked to indicate the area of the country in which they work. They were allowed to mark more than one answer, thus the cumulative percentage added up to greater than 100. From the choices provided, the resulting quantities were:

1. Northeast: 12.5%
2. Mid-Atlantic: 6.0%
3. Southeast: 28.3%
4. Midwest: 37.5%
5. South: 10.3%
6. Southwest: 14.1%
7. West: 13.0%
8. Northwest: 3.3%
9. International: 4.9%

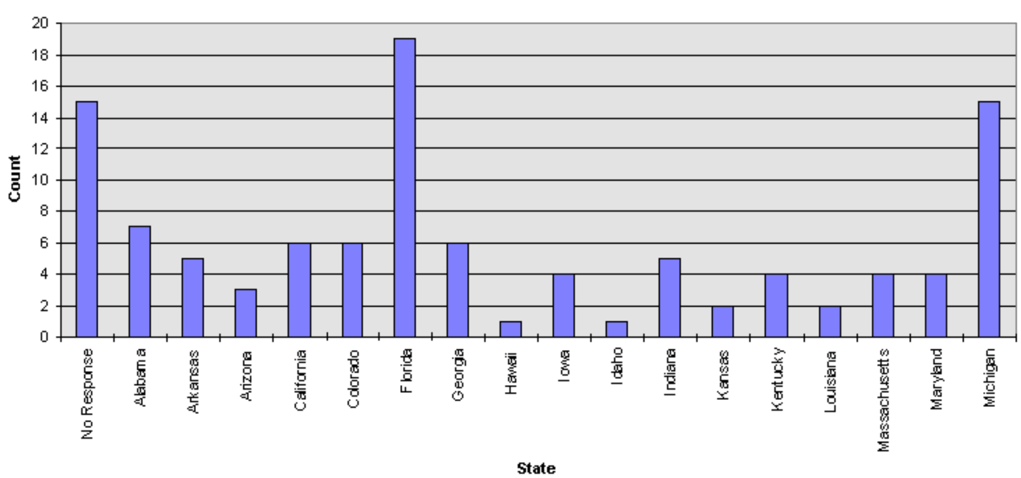

Figure 1a. *Distribution of Respondents by State.*

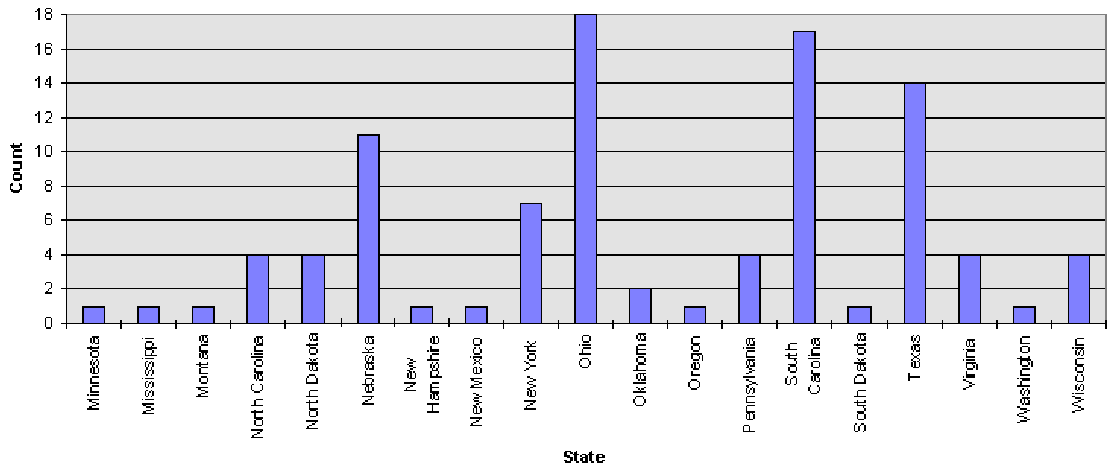

Figure 1b. *Distribution of Respondents by State.*

As shown in Figure 2, the majority of the respondents indicated that they were "General Contractors" (111), with the fewest respondents being "Specialty Contractors" (18). Twenty-seven educators also completed the survey.

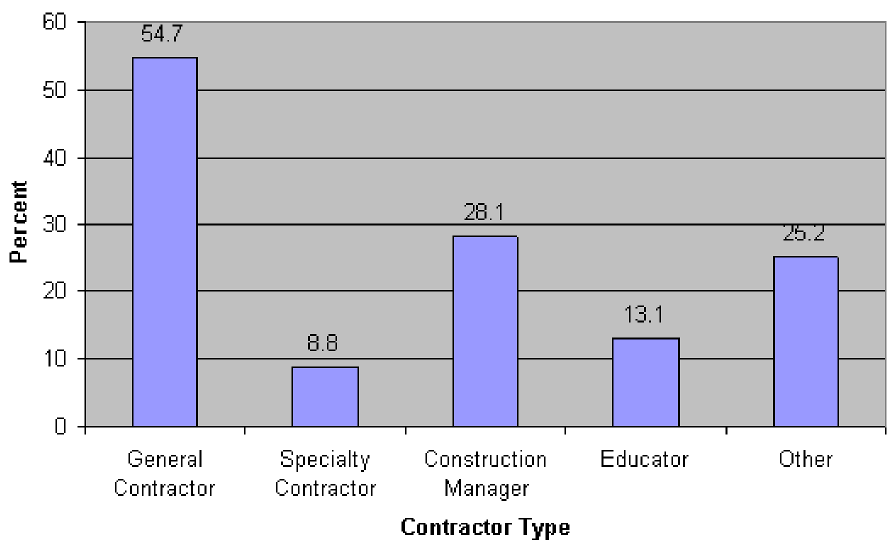

Figure 2. *Contractor Type for Which Respondents Work.*

The respondents were asked to approximate the size of their organization in terms of 1992 annual construction volume. Six different size categories were given as choices. Of the 206 total respondents, 31 did not answer this question. Educators accounted for the majority of non-responses. The resulting percentages were:

> Less than $1 million: 5.7%
> $1 million-$5 million: 12.0%

$5 million-$20 million: 18.3%
$20 million-$50 million: 17.7%
$50 million-$100 million: 8.6%
Greater than $100 million: 37.7%

The respondents were also asked to indicate what type of experience they have attained in various construction types. Respondents were able to mark all applicable answers, thus, as can be seen in Figure 3, the resulting percentages added up to more than 100. As can be expected, the vast majorities of the respondents have worked or are working in four construction types:

Residential: 99 respondents
Commercial: 170 respondents
Institutional: 166 respondents
Industrial: 132 respondents

An "Other" category was provided, and 25 respondents indicated that they have experience in construction types not listed in the survey.

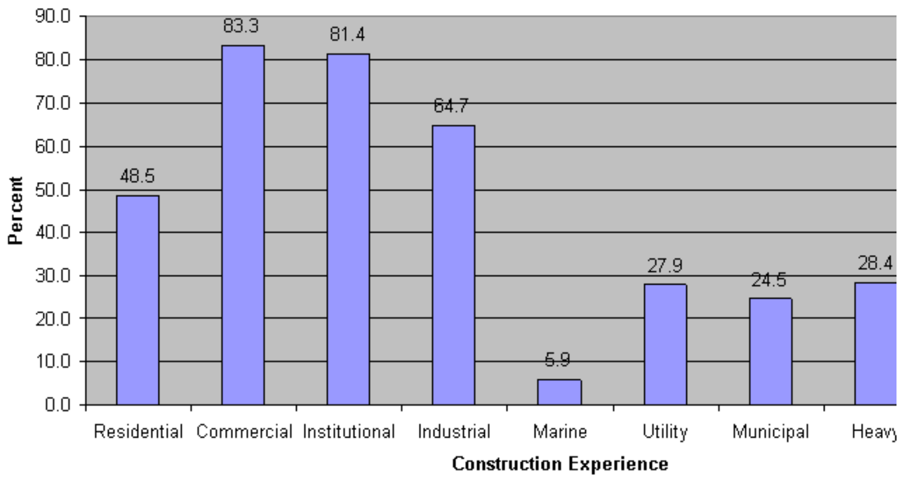

Figure 3. *Construction Experience of Respondents.*

Forty-one of the respondents fell between the ages of 41 and 45 and the remaining respondents were well distributed around this mode (see Figure 4). The vast majority of the respondents were male (97.6%), and Caucasian (98%). About one-half of the respondents had obtained a Bachelors degree (102). Program types for all higher degree categories (Associates, Bachelors, Masters, Doctorate) indicated that 74 respondents had obtained a degree in construction management or a related field. Some other program types represented were civil engineering (34 respondents), architecture (7 respondents), architectural engineering (5 respondents), and business/accounting/finance (18 respondents).

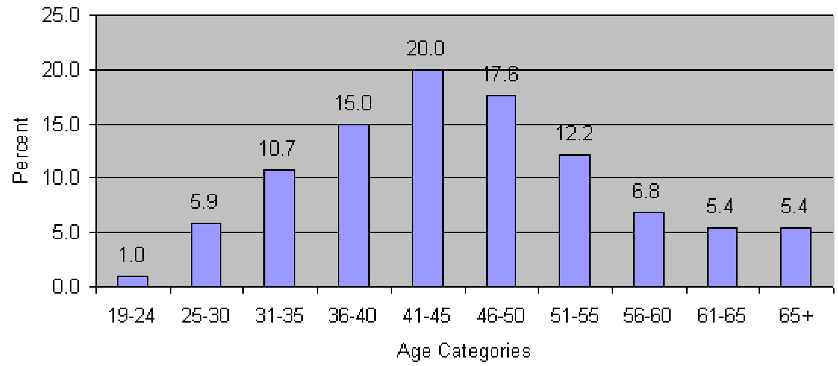

Figure 4. *Age Distribution of Respondents.*

Survey Format

The total survey consisted of several "forms" or sections. The first survey form dealt with various demographic issues, and the results from this form are presented above. The second survey form was the most significant. This form is known as the "Skills and Knowledge Instrument Validation Form,". For each of the 257 Performance Criteria, respondents were asked to indicate an answer to the following four questions:

1. Is the performance criterion relevant to the job you now perform? (Yes or No)
2. How critical do you feel the criterion is, as compared to the other criteria in this task, to the successful completion of a project? (Responses indicated on a five-point Likert Scale)
3. Are you now performing or have you ever performed this criterion? (Yes or No)
4. At what level are you now performing the criterion? (Capability or Understanding or Awareness)
5. The results from this survey form are presented in the following section.

Findings

The statistical analyses for the ten Duties are shown in Table 1. Given the process by which the survey was created, it is not surprising that the results indicated an overall positive response to the Duties, Tasks, and Performance Criteria described in the instrument. The design of the survey included only those items that the Commission felt would most likely be representative of the skills and knowledge required of this pool of respondents.

Respondents indicated that all ten Duties were "relevant to the job" they now perform approximately 80% of the time or more. Similar trends were found in the other response categories as well. The large majority of the respondents (68% or more) answered either "Moderately High" or "High" with respect to the criticality of each Duty. The remaining response categories showed that about 80% or more of the respondents "had performed or are presently performing" the Tasks and Criteria within each Duty. Further, about 62% or more of the respondents considered themselves to be performing these Tasks and Criteria at a level of "Capability" rather than "Understanding" or "Awareness".

Table 1

Statistical Summary of Duties

	JOB RELEVANCY		CRITICALITY							PERFORM		SKILL LEVEL				
	YES [1]	NO [2]	LOW [1]	MOD LOW [2]	NEUTRAL [3]	MOD HIGH [4]	HIGH [5]	MEAN	STD DEV	YES [1]	NO [2]	CAP [1]	UNDERST [2]	AWARE [3]	MEAN	STD DEV
Duty I	90.9%	9.1%	1.8%	5.0%	18.1%	30.6%	44.5%	4.108	0.945	94.3%	5.7%	75.9%	17.3%	6.8%	1.308	0.582
Duty II	81.4%	18.6%	3.7%	7.2%	18.1%	27.8%	43.2%	3.994	0.993	80.5%	19.5%	62.1%	24.0%	13.9%	1.519	0.717
Duty III	83.6%	16.4%	2.0%	5.9%	18.5%	30.1%	43.5%	4.071	0.970	83.6%	16.4%	67.4%	22.6%	10.1%	1.428	0.653
Duty IV	83.6%	16.4%	2.1%	6.9%	19.5%	31.0%	40.4%	4.010	0.957	85.6%	14.4%	67.4%	21.5%	11.1%	1.436	0.672
Duty V	79.7%	20.3%	3.1%	7.0%	21.1%	29.5%	39.2%	3.944	0.979	80.0%	20.0%	66.8%	20.1%	13.0%	1.372	0.688
Duty VI	81.5%	18.5%	2.0%	5.7%	18.4%	31.6%	42.4%	4.067	0.947	84.2%	15.8%	66.5%	20.6%	12.9%	1.465	0.683
Duty VII	90.7%	9.3%	0.7%	2.3%	12.2%	27.4%	57.3%	4.381	0.819	94.0%	6.0%	80.7%	11.2%	8.2%	1.276	0.603
Duty VIII	87.2%	12.8%	2.5%	6.0%	18.8%	30.7%	42.1%	4.039	0.979	86.5%	13.6%	73.2%	16.9%	9.9%	1.369	0.637
Duty IX	84.2%	15.8%	3.0%	5.7%	22.5%	33.9%	34.8%	3.916	1.017	79.6%	20.4%	65.1%	24.9%	10.0%	1.450	0.663
Duty X	95.1%	4.9%	1.2%	4.6%	15.9%	33.7%	44.6%	4.157	0.904	96.5%	3.5%	82.4%	12.2%	5.3%	1.229	0.530

To better clarify the results from this extensive survey and to uncover trends in the data, the researchers determined the rank order of the ten Duties for each of the four response categories (job relevancy, criticality, performance, and skill level). These rank orders are summarized in Table 2. The mean rank order for each of the ten Duties across all four of these response categories was then calculated. Based on this calculation, an overall rank order of the Duties was determined as shown in the right hand column of Table 2. The rank order of the Duties, and their associated descriptions, are as follows:

1. Duty X--Solve Problems and Make Decisions
2. Duty VII--Monitor Project Costs
3. Duty I--Plan Project Execution
4. Duty VIII--Create, Maintain and Enhance Effective Working Relationships
5. Duty III--Establish Responsibility for Operations and Communicate Relevant Information
6. Duty IV--Determine and Procure Physical Resources for the Execution of the Project
7. Duty VI--Monitor and Control the Use of Project Resources
8. Duty V--Develop Staffing and Subcontractor Requirements and
9. Duty IX--Develop Teams, Individuals and Staff to Enhance Performance
10. Duty II--Establish and Maintain Systems and Procedures to Operations

Although the survey results indicated that all ten of the Duties were considered to be very important, the summary presented in Table 2 revealed four distinct groupings as distinguished by the mean ranking calculation. In the first grouping, Duties X, VII, and I were ranked by the respondents no lower than first, second, or third in each response category. These rankings, and their resulting mean rankings of 1.25, 2.25, and 2.50 respectively, served to distinguish these three Duties from the rest. The second grouping included only Duty VIII with a mean ranking of 4.50. A third grouping by this analysis included Duties III, IV, and VI. The mean ranking of these three Duties ranged from 5.75 to 7.00. Finally, the fourth grouping included Duties V, IX, and II and included a range of mean rankings from 8.25 to 8.75. While this analysis does not detract from the importance of any of these Duties, this modified "forced ranking" does provide some insight into the relative importance of these characteristics of professional constructors.

Table 2

Overall Rank Order of Duties

	Job Relevancy	Criticality	Performance	Skill Level	Mean Rank	Overall Rank
FIRST GROUP						
Duty X	1	2	1	1	1.25	1
Duty VII	3	1	3	2	2.25	2
Duty I	2	3	2	3	2.50	3
SECOND GROUP						
Duty VIII	4	6	4	4	4.50	4
THIRD GROUP						
Duty III	6	4	7	6	5.75	5
Duty IV	6	7	5	7	6.25	6
Duty VI	8	5	6	9	7.00	7
FOURTH GROUP						
Duty V	10	9	9	5	8.25	8 (tie)
Duty IX	5	10	10	8	8.25	8 (tie)
Duty II	9	8	8	10	8.75	10

Discussion

The analysis of the results of this "Skills and Knowledge Survey" was designed to answer two research questions:

1. Are the ten "DUTIES" outlined in the AIC Constructor Certification Skills and Knowledge Survey perceived as being important to construction professionals?
2. Which of these ten "DUTIES" are perceived to be the most important?

Table 1 above summarizes the results in order to address the first research question. In general, all ten Duties were found to be:

1. very "job relevant" (79.7% to 95.1% indicating "Yes")
2. "moderately high" to "highly" critical to the "successful completion of a project" (means of 3.916 to 4.381 on a 5-point Likert scale)
3. performed by the great majority of the respondents (79.6% to 96.5% indicating "Yes")
4. performed primarily at the "capability" level (range of 62.1% to 82.4%)

While the results summarized at the Task level rather than at the Duty level were slightly more variable (see Appendix C), similar very positive ranges were reported indicating a high level of importance attached to nearly all 257 Performance Criteria. These data support the conclusion that the first research question--regarding the perception of importance of these ten Duties--was answered positively.

The analysis outlined in Table 2 was designed to address the second research question. With such a high level of support for all ten Duties, it was difficult to conclude from the raw data which of these responsibilities were more important than the others. In order to make this determination, a rank ordering procedure for each of the four response categories was used. The mean rank order of these four categories was used to place each of the ten Duties in one of four groupings:

1. First Group: Duties X, VII, and I
2. Second Group: Duty VIII
3. Third Group: Duties III, IV, and VI
4. Fourth Group: Duties V, IX, and II

This modified "forced ranking" procedure supported a conclusion that the above ranking represents a listing of the Duties in order of perceived importance. The "mean ranks" within each grouping were too similar to conclude that a notable difference existed among the Duties within each group. Differences between each of the four groupings did support the conclusion that Duties in the higher groups were considered to be more important. In answer to the second research question, this pool of respondents indicated that the first group of Duties above was considered to be the most important to successful professional practice.

Applying more general language to each Duty, one can more readily understand how each relates to the operations and management of the construction industry. In rank order, the ten Duties could be rephrased to read:

1. Duty X--Problem Solving
2. Duty VII--Estimating/Budgeting
3. Duty I--Project Management
4. Duty VIII--Work With People
5. Duty III--Organize People
6. Duty IV--Purchasing/Procurement
7. Duty VI--Cost/Schedule Control
8. Duty V--Staffing/Subcontractor Coordination and
9. Duty IX--Teamwork/Professional Development
10. Duty II--Support Operations

What results is a reasonable listing of those aspects of operations and management that parallels the job requirements of a modern construction organization. Considering the skills and knowledge required by such an organization, it is not surprising that the Duties included in the first group--problem solving, estimating/budgeting, and project management--were considered to be the most important. This rephrasing of the Duties may add some degree of content validity to these findings.

Areas of Future Research

Given the size of the database obtained from the Skills and Knowledge Survey--over 1200 items of information were collected from each respondent--there is great potential for additional research to be conducted on related topics. The following suggestions provide some direction to this future research.

Beyond an overall evaluation of the pool of raw data, several more detailed analyses might be conducted. Similar analyses could be done in an effort to compare responses among different groups of respondents. Those groups could be distinguished by:

1. the geographic region in which the respondents reside or work
2. the type of construction experience which they possess
3. the size of the company for which they work
4. the types of contractors for which they work (General Contractor, Specialty Contractor, etc.)

Such analyses should seek to identify any significant differences in the perceptions of required skills and knowledge when comparing one group of respondents to another.

As a necessary part of ensuring the quality of the entire certification process, the examinations must be tested for proper validity and reliability. It has been proposed that formalized pilot testing of both levels of the certification examinations be conducted prior to administering the first round examinations in November 1996. The primary objective of this pilot testing should be a determination of overall quality of the examinations as a valid measure of the requisite skills and knowledge to manage the construction process.

Upon completion of the first round examination series, a detailed item analysis of the examinations should be conducted. This analysis should review the results of each examination to ensure that each exam question is valid with respect to the overall objectives of the professional process. Doing so should give the Constructor Certification Commission the ability to evaluate both levels of certification examinations and update them where necessary.

All of the above research is intended to be additive in nature. In this way, each level of research or analysis will expand upon all former levels. The goal of this research has been to measure the perceptions of industry practitioners in an effort to establish the importance of those skills and knowledge outlined by the Constructor Certification Commission. Using these skills and knowledge to develop a series of certification examinations should provide the industry with something yet unknown--a tool that will allow for the elevation of standards in the industry to truly professional levels.

APPENDIX A

AIC Constructor Certification Skills and Knowledge Survey--Outline of Duties & Tasks
**NOTE: all Roman Numerals = "DUTY" (10 total)*
**NOTE: all letters = "TASK" (39 total)*

I. Plan Project Execution
  i. Identify & obtain relevant information to plan the project
  ii. Plan the Project
  iii. Estimate and schedule the project
II. Establish and Maintain Systems and Procedures to Support Operations
  i. Inspect, prepare and maintain project site.
  ii. Establish and maintain on-site administrative systems.
  iii. Establish and maintain systems for managing site safety and health.
  iv. Establish and maintain effective community and public relations.
  v. Establish and maintain quality systems & procedures.
  vi. Establish and maintain dimensional control.
III. Establish Responsibility for Operations & Communicate Relevant Information
  i. Assign responsibility & tasks for the completion of the project.
  ii. Communicate information relevant to methods, estimate & schedule to enable the completion of the project.
  iii. Communicate information on site organization and systems to enable the completion of the project.
IV. Determine & Procure Physical Resources for the Execution of the Project.
  i. Determine resource requirements for the project.
  ii. Procure materials for the execution of the project.
  iii. Procure plant & equipment for the execution of the project.
V. Develop Staffing & Subcontractor Requirements
  i. Define future personnel requirements.
  ii. Establishing hiring requirements consistent with governmental regulations.
  iii. Identify & select staff & sub-contractors.
VI. Monitor & Control the Use of Project Resources
  i. Monitor progress of the project.
  ii. Monitor & control materials.
  iii. Monitor & control subcontractors.
  iv. Monitor & control use and deployment of plant and equipment.
  v. Monitor & control personnel.
VII. Monitor Project Costs
  i. Monitor expenditures against budget.
  ii. Monitor and document work performed to enable reimbursement.
VIII. Create, Maintain & Enhance Effective Working Relationships
  i. Establish & maintain the trust & support of subordinates.
  ii. Establish & maintain the trust & support of one’s immediate manager.
  iii. Establish & maintain relationships with co-workers.
  iv. Identify & minimize interpersonal conflict.
  v. Implement disciplinary and grievance procedures.
  vi. Counsel and mentor staff.
  vii. Establish & maintain relationships with clients, their representatives and governmental agents.
  viii. Establish & maintain relationships with the general public.
IX. Develop Teams, Individuals & Staff to Enhance Performance
  i. Develop & improve teams through planning activities.
  ii. Identify, review & improve professional development activities for individuals.
  iii. Develop oneself within the job role.
X. Solve Problems & Make Decisions
  i. Conduct meeting and group discussions.
  ii. Effect problem solving & decision making.
  iii. Advise & inform others.

APPENDIX B

Statistical Summary of Duties and Tasks

	JOB RELEVANCY									PERFORM.		SKILL LEVEL				
	YES [1]	NO [2]	LOW [1]	MOD LOW [2]	NEUTRAL [3]	MOD HIGH [4]	HIGH [5]	MEAN	STD DEV	YES [1]	NO [2]	CAP [1]	UNDERST [2]	AWARE [3]	MEAN	STD DEV
DUTY I																
Task A	93.5%	6.5%	0.8%	2.3%	18.8%	31.8%	46.3%	4.203	0.847	96.5%	3.5%	83.4%	10.9%	5.7%	1.223	0.54
Task B	88.0%	12.0%	2.3%	7.0%	20.4%	31.0%	39.2%	3.976	1.015	91.0%	9.0%	68.7%	22.1%	9.2%	1.406	0.645
Task C	91.1%	8.9%	2.3%	5.6%	15.1%	29.0%	47.9%	4.146	0.972	95.5%	4.5%	75.7%	18.9%	5.4%	1.296	0.56
SUMM.	90.9%	9.1%	1.8%	5.0%	18.1%	30.6%	44.5%	4.108	0.945	94.3%	5.7%	75.9%	17.3%	6.8%	1.308	0.582
DUTY II																
Task D	86.2%	13.8%	2.8%	6.9%	17.0%	31.1%	42.1%	4.03	1.018	86.2%	13.8%	68.5%	20.9%	10.7%	1.424	0.672
Task E	87.1%	12.9%	3.9%	8.3%	24.1%	28.5%	35.2%	3.83	1.062	85.0%	15.0%	68.3%	20.0%	11.6%	1.432	0.69
Task F	83.8%	16.2%	1.9%	4.5%	15.7%	25.7%	52.2%	4.219	0.983	77.0%	23.0%	54.7%	28.4%	16.9%	1.623	0.756
Task G	66.7%	33.3%	11.1%	17.0%	25.5%	24.2%	22.3%	3.291	1.16	73.8%	26.2%	59.8%	23.0%	17.2%	1.578	0.75
Task H	87.8%	12.2%	1.3%	3.0%	13.4%	29.2%	53.1%	4.294	0.842	84.9%	15.1%	62.0%	28.4%	9.6%	1.478	0.664
Task I	77.0%	23.0%	1.4%	3.5%	13.1%	27.8%	54.2%	4.298	0.893	76.2%	23.8%	59.5%	23.4%	17.1%	1.578	0.768
SUMM.	81.4%	18.6%	3.7%	7.2%	18.1%	27.8%	43.2%	3.994	0.993	80.5%	19.5%	62.1%	24.0%	13.9%	1.519	0.717
DUTY III																
Task J	82.8%	17.2%	0.9%	5.7%	17.4%	31.3%	44.8%	4.135	0.933	80.3%	19.7%	69.1%	21.5%	9.5%	1.405	0.653
Task K	89.0%	11.0%	1.7%	4.7%	16.6%	30.2%	46.7%	4.151	0.915	92.8%	7.2%	76.7%	16.8%	6.5%	1.299	0.58
Task L	79.0%	21.0%	3.4%	7.2%	21.5%	28.9%	39.0%	3.928	1.061	77.8%	22.2%	56.3%	29.5%	14.2%	1.581	0.725
SUMM.	83.6%	16.4%	2.0%	5.9%	18.5%	30.1%	43.5%	4.071	0.970	83.6%	16.4%	67.4%	22.6%	10.1%	1.428	0.653
DUTY IV																
Task M	86.4%	13.6%	2.6%	6.4%	20.5%	32.4%	38.0%	3.967	0.971	87.8%	12.2%	67.8%	23.6%	8.7%	1.409	0.643
Task N	86.7%	13.3%	0.9%	5.5%	16.1%	31.2%	46.3%	4.173	0.853	92.4%	7.6%	74.2%	16.4%	9.4%	1.35	0.629
Task O	77.6%	22.4%	2.7%	8.9%	21.9%	29.5%	36.9%	3.889	1.048	76.6%	23.4%	60.2%	24.6%	15.1%	1.55	0.743
SUMM.	83.6%	16.4%	2.1%	6.9%	19.5%	31.0%	40.4%	4.010	0.957	85.6%	14.4%	67.4%	21.5%	11.1%	1.436	0.672
DUTY V																
Task P	82.6%	17.4%	2.1%	6.6%	21.2%	33.2%	36.9%	3.962	0.987	84.6%	15.4%	70.6%	17.7%	11.7%	1.142	0.692
Task Q	69.9%	30.1%	5.1%	10.1%	28.4%	28.1%	28.3%	3.641	1.119	64.9%	35.1%	50.2%	30.1%	19.6%	1.693	0.779
Task R	86.5%	13.5%	2.2%	4.4%	13.7%	27.3%	52.3%	4.23	0.831	90.4%	9.6%	79.7%	12.6%	7.7%	1.28	0.594
SUMM.	79.7%	20.3%	3.1%	7.0%	21.1%	29.5%	39.2%	3.944	0.979	80.0%	20.0%	66.8%	20.1%	13.0%	1.372	0.688
DUTY VI																
Task S	89.7%	10.3%	1.0%	4.4%	16.1%	31.2%	47.3%	4.195	0.904	93.9%	6.1%	79.7%	13.0%	7.3%	1.275	0.583
Task T	80.4%	19.6%	1.7%	7.8%	21.5%	31.2%	37.9%	3.956	0.957	86.8%	13.2%	63.4%	24.8%	11.9%	1.486	0.69
Task U	87.0%	13.0%	0.6%	2.4%	13.1%	30.9%	53.0%	4.331	0.822	89.0%	11.0%	76.2%	15.5%	8.3%	1.323	0.621
Task V	69.9%	30.1%	5.0%	7.9%	22.5%	29.9%	34.8%	3.819	1.104	68.5%	31.5%	47.7%	26.7%	25.5%	1.779	0.827
Task W	80.5%	19.5%	1.6%	5.8%	18.9%	34.6%	39.1%	4.036	0.946	82.8%	17.2%	65.5%	22.8%	11.7%	1.46	0.694
SUMM.	81.5%	18.5%	2.0%	5.7%	18.4%	31.6%	42.4%	4.067	0.947	84.2%	15.8%	66.5%	20.6%	12.9%	1.465	0.683
DUTY VII																
Task X	91.4%	8.6%	0.9%	2.1%	12.8%	30.0%	54.1%	4.341	0.819	94.7%	5.3%	79.9%	12.4%	7.7%	1.279	0.596
Task Y	90.0%	10.0%	0.5%	2.5%	11.6%	24.8%	60.5%	4.42	0.818	93.3%	6.7%	81.4%	10.0%	8.7%	1.273	0.61
SUMM.	90.7%	9.3%	0.7%	2.3%	12.2%	27.4%	57.3%	4.381	0.819	94.0%	6.0%	80.7%	11.2%	8.2%	1.276	0.603
DUTY VIII																
Task Z	91.7%	8.3%	1.4%	4.2%	15.0%	32.8%	46.6%	4.19	0.901	93.0%	7.0%	82.5%	11.6%	5.8%	1.24	0.589
Task AA	92.5%	7.5%	0.9%	6.1%	17.6%	33.0%	42.3%	4.102	0.912	95.9%	4.1%	78.9%	15.7%	5.4%	1.262	0.55
Task AB	97.2%	2.8%	0.7%	4.5%	13.8%	32.5%	48.5%	4.235	0.875	99.2%	0.8%	85.9%	8.1%	6.0%	1.203	0.53
Task AC	87.4%	12.6%	2.9%	5.9%	20.0%	31.6%	39.6%	3.99	1.006	87.6%	12.4%	68.4%	21.0%	10.6%	1.424	0.672
Task AD	79.2%	20.8%	4.5%	7.5%	22.4%	30.7%	35.0%	3.843	1.1	71.2%	28.8%	57.0%	25.5%	17.5%	1.608	0.768

Task AE	76.5%	23.5%	4.3%	7.0%	23.2%	30.1%	35.4%	3.854	1.088	71.8%	28.2%	61.9%	23.9%	14.3%	1.524	0.73
Task AF	94.6%	5.4%	1.0%	2.7%	11.6%	25.7%	59.1%	4.392	0.834	95.4%	4.6%	85.0%	9.1%	5.9%	1.208	0.532
Task AG	78.6%	21.4%	4.5%	9.7%	26.6%	28.8%	30.3%	3.706	1.116	77.5%	22.5%	65.9%	20.2%	13.9%	1.48	0.726
SUMM.	87.2%	12.8%	2.5%	6.0%	18.8%	30.7%	42.1%	4.039	0.979	86.5%	13.6%	73.2%	16.9%	9.9%	1.369	0.637
DUTY IX																
Task AH	86.1%	13.9%	2.8%	6.2%	22.6%	33.6%	34.9%	3.914	1.02	78.3%	21.7%	66.2%	24.6%	9.3%	1.431	0.657
Task AI	76.7%	23.3%	4.2%	6.1%	25.5%	35.2%	29.0%	3.787	1.047	71.4%	28.6%	58.9%	27.1%	13.9%	1.553	0.725
Task AJ	89.7%	10.3%	2.1%	4.9%	19.4%	33.0%	40.5%	4.047	0.983	89.0%	11.0%	70.2%	23.0%	6.9%	1.367	0.607
SUMM.	84.2%	15.8%	3.0%	5.7%	22.5%	33.9%	34.8%	3.916	1.017	79.6%	20.4%	65.1%	24.9%	10.0%	1.450	0.663
DUTY X																
Task AK	96.2%	3.8%	1.6%	4.7%	14.4%	32.1%	47.2%	4.184	0.926	97.3%	2.7%	84.4%	10.3%	5.3%	1.209	0.521
Task AL	95.7%	4.3%	0.8%	3.8%	13.1%	36.7%	45.6%	4.222	0.848	95.6%	4.4%	83.2%	12.0%	4.8%	1.216	0.514
Task AM	93.3%	6.7%	1.3%	5.3%	20.1%	32.3%	41.0%	4.064	0.938	96.5%	3.5%	79.7%	14.4%	5.8%	1.262	0.556
SUMM.	95.1%	4.9%	1.2%	4.6%	15.9%	33.7%	44.6%	4.157	0.904	96.5%	3.5%	82.4%	12.2%	5.3%	1.229	0.530

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Long-term Construction Contracts: The Impact of Tamra '88 on Revenue Recognition

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This article discusses the accounting process for a long-term construction contract, and the effect of recent income tax reform on revenue recognition for income tax liability purposes. The Tax Reform Act of 1986 (TRA '86) introduced several significant changes in tax accounting for long-term construction projects. Further tax legislation reform was promulgated via the Technical and Miscellaneous Revenue Act of 1988 (TAMRA '88). Prior to the promulgation of these income tax reform acts, a contractor could use the percentage-completion method for reporting income to creditors and investors, while using the completed-contract method for income tax recognition purposes. After TRA'86 and ending with TAMRA'88 tax legislation, the contractor is now required by law to utilize a 90/10 split for an income recognition schedule if a contract is longer than two years and the contractor has sales of more than $10,000,000 per year.

Key Words: Construction Contract, Percentage-Completion Method, Completed-Contract Method, Long-Term Construction Accounting

Introduction

As a construction project progresses toward completion, the contractor is periodically compensated for construction expenditures. The income generated by completed work is termed earned value. While earned value for completed work is easily determined, income recognition for work in process is more complex. In order to deal with this complexity, the United States Treasury Department has allowed the contractor to use either the percentage-of-completion method of accounting or an alternative method of financial reporting termed completed contract (Pirrong, 1987). The primary difference between the two methods involves the timing of revenues and expenses for income tax purposes. The Tax Reform Act of 1986, and the Technical and Miscellaneous Revenue Act of 1988 have significantly modified revenue recognition for long-term contracts and, thereby dramatically altered how a contractor currently accounts for contract income and the subsequent tax liability that incurs.

The purpose of this article is to present traditional approaches of accounting for long-term construction contracts, and to illustrate how recent tax legislation has materially affected income tax liability for construction firms.

Generally Accepted Accounting Principles

Financial accounting for a construction firm is the process of identifying, measuring, recording, and communicating economic data to management for decision-making purposes (Hobbs, & Moore, 1984). To accomplish this task, the construction accountant utilizes the following three financial statements: (a) the income statement, (b) the balance sheet, and (c) the statement of cash flow (Reynolds, Hillman, & Kochanek, 1988). The income statement summarizes the results of the income producing operations for a particular accounting period (Thomsett, 1987). The balance sheet recapitulates the financial position of the firm at a particular economic point in time (Halpin, 1985; Adrian, 1988). The statement of cash flow summarizes and predicts the expected cash inflows and outflows for the company during a designated interim accounting period (Gitman, 1989; Ross, Westerfield, & Jordan, 1991).

Financial transactions occur on a daily basis for a construction organization. Examples of such transactions are: (a) material purchases, (b) leases for equipment, and (c) vendor invoices. These types of financial transactions are generally referred to as external accounting transactions. Internal accounting transactions record: (a) payroll for employees, and (b) depreciation expense for capital assets (Hobbs et al, 1984).

The accounting cycle for a construction company is based on the duration period of individual construction contracts (Callan, & Rice, 1993). The reporting methodology that directs the presentation of such financial information is termed generally accepted accounting principles (GAAP). The American Institute of Certified Public Accountants (AICPA) first promulgated these principles in 1964 as a Special Bulletin. GAAP was later adopted as an appendix to the Accounting Principles Board (APB) Opinion No.6. In short, GAAP sets forth the fundamental accounting principles and practices required of an economic entity that publicly publishes financial statements (Kieso, & Weygandt, 1983).

The first element in the GAAP framework is the accounting principle matching. The matching technique associates expenses with revenues. Thus, expense recognition is a function of revenue recognition. The matching technique is fundamental to accrual basis accounting and serves as the primary difference between it and the method termed cash basis accounting (Reynolds et al, 1988; Thomsett, 1987).

The element of consistency provides for comparability of financial information from one period to the next in the sequence of productions and operations cycles. The intent of the consistency principle is to keep the reporting of financial information consistent across accounting periods so that comparable basis financial analyses can be made regarding the economic activity of the construction organization across time.(Kieso et al, 1983; Neveu, 1985).

The principle of materiality relates to the importance of a particular financial transaction. A financial transaction is considered significant if its inclusion or omission would influence or change the decision making of the end user (Welsch et al, 1979). Conservatism is an accounting principle that disallows overstatement of financial information. The principle of conservatism advances the accounting axiom that assets and income of the firm will be reported at the lowest probability of overstatement (Hobbs et al, 1984).

Another element that formulates the framework of GAAP is the principle of periodicity. Because financial statements are prepared at regularly specified time intervals throughout the lifetime of a construction firm, the principle of of periodicity maintains that items of expense and revenue be properly recorded in the accounting period incurred for proper income recognition and subsequent tax determinations (Reynolds et al, 1988).

The last GAAP element is revenue realization. Under the paradigm of accrual basis accounting, revenue is realized only when earned (Hobbs et al, 1984). That is, the point in time when the sale for services or products has been transferred.

Financial Accounting Methods

There are two basic accounting methods available to the construction contractor for expense and revenue recognition purposes (Reynolds et al, 1987; Adrian, 1988). One method is termed the cash basis of accounting. The second accounting method is the accrual basis approach. The fundamental distinction between cash basis accounting and that of accrual basis accounting lies in the recognition, recording, matching, and reporting time of a financial transaction (Kieso et al, 1983).

Under the cash basis, both revenue and expenses are recognized in the accounting period in which cash is received or remitted. Income from operations is thus calculated as the difference between cash collected and cash disbursed for the accounting period. Financial reporting employing this method does not accurately reflect the true financial position of the construction firm (Hobbs et al, 1984; Bazley et al, 1991).

Conversely, the accrual basis of accounting recognizes revenue earned in a period with those expenses incurred in that period. Therefore, under the accrual method it is immaterial when cash is received or remitted. Thus, under GAAP standards, accrual accounting recognizes revenue with financial transactions in the accounting period that affixes a right of title to receive such revenue for labor, services, and materials rendered to date (Bazley et al, 1991).

The important distinction between these two accounting methodologies lies in the ability of management to properly recognize the true financial position and structure of the firm relative to its assets (receivables) and liabilities (payables) composition. The failure of the cash basis approach is in not recognizing cash collectibles and cash disbursements until actually transacted.

Methods of Accounting for the Construction Industry

Accounting for a construction firm is predicated solely on the concept profit center measurement. AICPA Statement of Position (SOP) 81-1 defines a profit center as a single contract for construction. By cost accounting definition, a profit center is any subunit or segment of an organization that is assigned both revenues and expenses for an activity or group of activities that generate profits or losses that can be segregated and separately measured and analyzed by its profit contribution to the organization (Deakin and Maher, 1987). The AICPA promulgation of the Audit and Accounting Guide "Construction Contractors" identifies four fundamental types of construction contracts for profit center measurement. These contract types are classified according to different pricing arrangements and titled as: (a) fixed-price or lump sum, (b) time-and-material contracts, (c) cost-type (fee, or percentage), and (d) unit price contracts (Callahan et al, 1993). The focus on individual contracts (profit center accounting) is a unique aspect of financial reporting for the construction industry. Thus, the accounting methodologies utilized by a construction organization to recognize income from construction operations differs significantly from that of other methods employed in different business environments (AICPA, Statement of Position 81-1, 1993).

Income recognition in the construction industry is a process that involves measuring financial results for operation across long-term duration periods and accurately assigning these results to relatively short-term accounting periods in compliance with the matching principle under GAAP (Callan, et al, 1994). Thus, the uniqueness of accounting for a construction firm centers on the problem of correctly determining revenue, expenses, and hence, gross profits in the appropriate accounting period. Recognition has to do with income tax liability (Callan, et al, 1994). For smaller construction contractors, this problem of revenue recognition is not significant. In fact, as a result of the Tax Reform Act of 1986, a contractor whose annual gross revenues average less than $10 million per year and with contracts that have duration periods less than two years must use the traditional accrual or cash basis of accounting when recognizing gross profit (Pirrong, 1987). Therefore, accounting for revenue, cost, and gross profit is performed identically to that of any other business organization where revenue and expenses do not exceed one year (Halpin, 1985; Adrian, 1988; AICPA, 1993). The AICPA has not promulgated or defined what exactly constitutes a long-term contract. The general rule applied however to the construction industry is any contract that exceeds one year in duration.Revenue recognition for a long-term construction contract is complicated by progress billings. Typically, a contractor unbalances progress payment billings in relation to actual work performed. Therefore, the actual cost incurred may significantly overstate contract profits in the earlier stages of construction and, thus, understate profits in later phases (Combs & Palmer, 1984; Halpin, 1985). The primary reason a contractor accelerates billings ahead of actual cost is to enhance the working capital position of the firm so that the construction project itself may be financed from its own internally generated cash flow.

The two generally accepted accounting methodologies for long-term construction contract financial reporting are: (a) the Percentage of Completion Method, and (b) the Completed Contract Method (American Institute of Certified Public Accountants, Accounting Research Bulletin No. 45, 1955). A modification of the percentage-of-completion method termed the Units of Delivery Method was pronounced in an AICPA publication titled Audits of Government Contractors (Callan et al, 1994; Combs et al, 1984).

Accounting Research Bulletin (ARB) 45, in conjunction with SOP 81-1, requires a contractor to use either method of long-term contract accounting when the contracted for work exceeds one year (this definition has been redefined by the Tax Reform Act of 1986). ARB 45 also defines the conditions in which either method of contract accounting should be applied in actual practice. Moreover, SOP 81-1 at paragraph 21, maintains that the two methods are not acceptable alternates under the same set of contractual conditions (AICPA, 1993).

AICPA guidelines clearly establish a preference for use of the percentage of completion (POC) method for profit center measurement on the theory that revenues and gross profits are earned as the job progresses through time. Conversely, the completed contract method of accounting recognizes contract gross profit only when the project is contractually completed. Thus, construction cost are accumulated in an inventory account referred to as Construction-in-Process, while progress billings are accumulated in a contra inventory account titled Billings on Construction in Process (Hickok, 1985; Kieso et al, 1983; Combs et al, 1984).

In practice, approximately 90% of the construction companies utilize the POC method (AICPA, 1993). Reason being is that the POC method is used to present financial reporting and the CC method is used for income tax reporting purposes. The advantage of utilizing the two methods for the different financial purposes is the ability to defer the tax liability until the end of the contract while still recognizing the income in financial reports as earned for the present period.

Percentage-of-completion Method

The POC method recognizes revenues, costs, and gross profits as work progresses toward completion on a long-term contract (Millner, 1988; Lucas, 1973). To defer recognition of these items until completion of the entire contract is to misrepresent the efforts (cost) and accomplishments (revenues) from construction operations for the interim accounting periods (Halpin, 1988; Thomsett, 1987). In order to apply the POC method, one must have some basis or standard for measuring the progress toward completion at particular interim dates (Thomsett, 1987). Therefore, the SOP 81-1 recommends the POC method as the preferable accounting methodology for long-term contracts (profit center) when estimates are reasonably dependable. Moreover, SOP 81-1 sets forth certain conditions that should exist in order for a construction company to apply such a method. Such provisions are: (a) the contract includes provisions that clearly specify enforceable rights regarding goods or services to be rendered under the terms and conditions of the agreement, (b) the seller of the goods and services can be reasonably certain that the purchaser will satisfy the contractual obligations under the contract, and (c) the contractor reasonably expects to perform the contractual obligations (AICPA, 1993).

With the POC method, gross profits and revenues are recognized for a given contract on a proportional basis in relation to the progress yielded by construction operations towards completion of same (Bazeley et al, 1991). The advantage of this accounting paradigm is that it reflects actual revenue earned on a particular project on a current basis and, as such, results in an improved cash flow reporting model for the contractor (Halpin, 1988). According to the AICPA (1993), the disadvantage of the methodology is that it relies on cost estimates by management that are subject to a high degree uncertainty. The gross profit margin accrued is allocated to each accounting period based on the portion of the projected estimated cost to be complete, which is the ratio of the current periods actual contract cost to the total estimated cost of the contract. Because of the proportional recognition of gross profit each period, the POC method is essentially an accounting hybrid of the cash Basis and the accrual basis of accounting. As such, it recognizes revenue, expenses, and income throughout the entire building contract period for completed work in place (AICPA, 1993; Adrian, 1988, Welsch et al, 1979). The POC method is dissimilar however to the aforementioned accounting methods because contract income is realized on the basis of contract value earned rather than cash collected or billed receivables to date. The complication and measurement associated with a long-term construction contract exist because of the unconventional construction in process inventory account. Since inventory valuation directly affects contract income measurement, tax liability, and reporting of the financial position of the construction firm (Pirrong, 1987). The estimated amount of income recognized each period is accrued by debiting Construction-in-Process and simultaneously crediting Income on Construction (profit centers). The latter account is subsequently closed at the end of the accounting period and is reported on the income statement for the period in question (Combs et al, 1984; Kieso et al, 1983; Welsch et al, 1979; Thomsett, 1987). It is the recognition of the appropriate income and inventory accounts and, hence the recording of over billings and under billings that separates the POC method from the accrual method of accounting (Bazley et al, 1991; Halpin, 1985; Adrian, 1988).

There are several techniques utilized by the accounting profession when employing the POC method to establish value earned on a profit center. These techniques are: (a) the cost-to-cost method, (b) the effort-expended method, and (c) the units-of-work performed (Callan, 1994; Combs et al, 1984). The objective under each of these various techniques is to measure the extent of progress in terms of costs, units, or valued added for a given profit center for the range amounts in the appropriate accounting period. These POC techniques utilize the concepts of input and output measures. Such measures are categorized as costs incurred, labor hours worked, tons produced, or miles of pavement installed. Input measures are dimensionally classified as efforts devoted to completion of the contract. Conversely, output dimensions are categorized as results obtained (Kieso et al, 1983; Bazley et al, 1991).

The difficulty in using the POC techniques lies with the ability of management to make reasonably accurate and quantifiable cost estimates of construction progression towards completion of the contract, and from difficulty in projecting the final gross profit with some degree of accuracy for income tax purposes (Hickok, 1982; Wright and Mazurkiewicz, 1988). Owing to current tax legislation (starting with Tax Reform Act of 1986), and because the AICPA (1993) advocates the use of the cost-to-cost (CTC) method most Certified Public Accountants prefer the CTC technique (Pirrong, 1987; Adler, 1989; Accounting Review Board No. # 45). As a result, the POC method under the CTC technique is the most often applied methodology in the accounting profession when attempting to ascertain gross profits from a construction contract (Adler, 1989). Therefore, the following presentation and discussion of the POC method will be predicated on the basis of the CTC technique of accounting for revenues, expenses, and gross profits for a long-term contract.

Under the CTC technique, the POC method is quantitatively measured by comparing costs incurred to date against a most recent estimate of the total costs to complete a contract. The equation to accomplish this calculation is:

$$\frac{(CIEP)}{(RETC)} * (100) = PC$$

where:
CIEP = Costs incurred end of period
RETC = Recent estimate of total costs
PC = Percent Complete

The percentage of costs incurred to date is then multiplied by the total contract revenue to estimate total gross profit on the contract and, thereby derives the revenue and the gross profit amounts to be recognized to date for financial reporting purposes. The amounts of revenue and gross profit recognized each year are computed as follows:

$$\frac{(CIEP)}{(RETC)} * (ETRC) - (TRRPP) = CPR$$

where:
CIEP = Costs incurred end of period
RETC = Recent estimate of total costs
ETRC = Estimated total revenue (or gross profit) from the contract
TRRPP = Total revenue (or gross profit) recognized in prior periods
CPR = Current period revenue (or gross profit)

The following example, Tables 1 through 9, demonstrates the technique of recognizing revenues, costs, and gross profits for interim construction operations under the POC method when utilizing the CTC technique of accounting for a long-term construction contract. Table 1 displays the calculations for the percentage complete amount for each year the contracted for work is being completed for income recognition purposes.

On the basis of the data display above, journal entries would be entered into the appropriate accounts to reflect financial transactions that impact the accounts: a) cost of construction, b) progress billings on the contract, and c) recording of collections. Table 2 provides a summary of these typical journal transactions. In 1993, the cost of completion calculation for the contract is derived by $2,000,000/ $5,000,000, which equals 40 percent complete. This earned value is predicated on $2,000,000 in cost incurred to date on projected (estimated) total cost of $5,000,000. Therefore, revenue for 1993 is based on $5,500,000 contract price to date multiplied by the 40 percent complete, which equates to recognized revenues for the accounting period 1993 in the amount of $2,200,000. Multiplying the 40 percent complete factor by the estimated gross profit projection for the contract period 1993 subsequently derives the annual gross profit before taxes. On the basis of data derived in Table 1, subsequent years percentage completion calculations and associated revenue and gross profit recognition are derived and displayed in Table 3.

The costs incurred to date, when taken as a proportion of the estimated total costs to be incurred to complete the contract, measures the extent of construction progress toward completion of the contract. Table 3 displays the calculation necessary for recognition of estimated revenue and gross profit for each year of the contract.

As construction operations progress towards completion of the project, journal entries are routinely made through out the year to recognize revenue and the applicable proratable amount of generated gross profit in each year in order to record final completion of the contract in the last year. The total amount of gross profit recorded in the last year is the amount the contractor would report for income tax purposes. Displayed in Table 4, is the revenue generated from the long-term contract, which is credited in the amounts calculated in Table 3, while gross profit is computed as above and then debited to Construction-in-Process account.

Table 1

Percentage of Completion: Cost-to-Cost Method

Facts:
Aggie Construction Company has a contract to build an office building with a starting date of April, 1993, and a completion date of October 1995. Contract price is $5,500,000. Contract total cost is $5,000,000.

	1993 $(000's)	**1994 $(000's)**	**1995 $(000's)**
Cost to date	2,000	3,916	5,050
Estimated cost to compete	4,000	1,134	---
Progress billing during year	1,400	2,900	1,200
Cash collected during year	1,250	2,250	2,000

	1993 $(000's)	**1994 $(000's)**	**1995 $(000's)**
Contract Price	5,500	5,500	5,500
Less estimated cost:			
Cost to date	2,000	3,916	5,050
Estimated costs to complete	4,000	2,134	----
Estimated total costs	5,000	5,050	5,050
Estimated total gross profit	500	450	450
Percent Complete:	2,000	3,916	5,050
	5,000	5,050	5,050
	40%	77.5%	100%

Table 2

Journal Entries

	1993 $(000's)	**1994 $(000's)**	**1995 $(000's)**
Recording Construction Cost			
Construction in Progress	2,000	1,916	1,134
Materials, cash, payables etc.	2,000	1,916	1,134
Recording Progress Billings			
Accounts Receivable	1,400	2,900	1,200
Construction Billings in Progress	1,400	2,900	1,200
Recording Collections			
Cash	1,250	2,250	2,000
Accounts Receivable	1,250	2,250	2,000

The difference between the amounts recognized each year for revenue and gross profit is debited to a nominal account, Construction Expenses (cost of goods sold), which is then reported to the income statement for the accounting period and offset against profits in same period for income tax purposes.

As construction progresses towards completion of the contract, cost are accumulated in the Construction-in-Process account in order to maintain a record of total costs for construction operations to date. In accounting theory, under the POC method, a series of sales transactions

Table 3

Revenue Recognition

	1993 $(000's)	1994 $(000's)	1995 $(000's)
Recognized Revenue:			
1993 $5,500,000 * 40%	$ 2,200		
1994 $5,500,000 * 77.5%		$ 4,262	
(Less 1993 Revenue)		2,200	
Revenue in 1994		$ 2,062	
1995 $5,500,000 * 100%			$ 5,500
(Less 1993, 1994 Revenue)			4,262
Revenue in 1995			$ 1,238
Recognized Gross Profit			
1993 $500,000 * 40%	$ 200		
1994 $450,000 * 77.5%		$ 349	
(Less 1994 Gross Profit)		200	
Gross Profit 1994		$149	
1995 $450,000 * 100%			$ 450
(Less 1993,1994 Gross Profit)			349
Gross Profit 1995			$101

takes place each progress payment and therefore the Construction-in-Process account is not affected by the entry to recognize construction expense or profit. Because the account, Construction-in-Process, functions as an inventory cost account, the contract cost cannot therefore be removed until the construction is completed and transferred to the owner at the date of final completion. Table 5 displays a summary of the construction-in-Process account over the three-year construction duration period of the project.

When examining financial statements for a contractor under the POC method of accounting, one will find that both accounts receivable and the inventory accounts continue to be carried on the books at the same time. Therefore, by subtracting the balance in the billings account from Construction-in-Process, double counting of the balance in the inventory account is avoided.

Table 4

Revenue and Gross Profit Entries

	1993 $ (000's)	1994 $ (000's)	1995 $ (000's)
Recognizing revenue and Gross Profit			
Construction in Process (Gross Profit)	$ 200	$ 149	$ 101
Construction Expense	2,000	1,916	1,134
Long-term Contract Revenue	2,200	2,065	1,285
Recording Final Approval of Contract			
Billing on Construction in Process		$ 5,500	
Construction in Process			5,500

Table 5

Construction in Progress Account

CONSTRUCTION IN PROGRESS		
1993	Construction Costs	$ 2,000,000
1993	Recognized Gross Profits	200,000
1994	Construction Costs	1,916,000
1994	Recognized Gross Profits	148,750
1995	Construction Costs	1,134,000
1995	Recognized Gross Profits	101,250
TOTAL		$ 5,5000,000
12/31/95 Close Completed Contract		$ 5,5000,000
Total		$ 5,5000,000

Table 6

Unbilled Portion of Contract

Unbilled Balance on Contract Price 12/31/93 Contract Revenue Recognized to Date:		
$ 5,500,000 *	$ 2,000,000 $ 5,000,000	= $ 2,200,000
Billing Date	1,4000,000	
Unbilled Contract Amount	$ 800,000	

The mathematical difference between the Construction-in-Process account and the billings on Construction-in-Process account is reported on the balance sheet as a current asset when the account has a debit balance. Conversely, the account is reflected on the balance sheet as a current liability if there exist a credit balance. When the costs incurred to date plus gross profit recognized to date (the balance in Construction-in-Process) exceed the billings on contract, the excess is reported as a current asset titled: Costs and Recognized Profit in Excess of Billings. Thus, the unbilled portion of a contract can be calculated at any time by subtracting the billings to date account balance from the revenue recognized to date account balance. Table 6 provides this calculation for the contract year 1993.

An antithetical financial condition occurs when billings exceed cost incurred and gross profit to date. This condition is displayed in Figure 1. This excess in billings is reported as a current liability titled: Billing in Excess of Costs and Recognized Profit. Table 7 displays financial results across a three-year period for a long-term contract.

In summary, when using the POC method of accounting, revenues, expenses, and gross profits are recognized in each accounting period throughout the duration of the contract. Because of the proportional basis of recognizing income, the earned value of each period is treated as a continual sales transaction similar to that under the accrual methodology of recognizing income. Therefore, actual income from the contract is not recognized until final completion of the contract is achieved. The estimated amount of income is predicated on the estimated percentage of cost incurred each period to that of the projected estimate to complete, with the percentage complete being applied against contract price to recognize revenues for the accounting period in question.

Table 7

Financial Statement

Aggie Construction Company
Financial Statement Presentation - Percentage-of-Completion Method

	1993 $(000's)	1994 $(000's)	1995 $(000's)
Income Statement			
Long-term Contract Revenue	$ 2,200	2,062	1,238
Costs of Construction	2,000	1,916	1,134
Gross Profit	200	149	101
Balance Sheet (12/31)			
Current Assets:			
Accounts Receivable	150	1,450	
Inventories			
Construction in Progress	2,200		
Less: Billings	1,400		
Costs and recognized profit in excess of billings	200		
Current liabilities:			
Billings ($4,300,000) in excess of costs and recognized profit ($4,264,750)		35	

Completed-contract Method

Under the Completed-Contract (CC) method, total revenue, and gross profit are recognized only at the point of sale, that is, when the construction contract is substantially complete (Combs et al, 1984). ARB #45 states that this method is preferable to POC method only if a lack of dependable estimates or the existence of inherent hazards causes forecasts to be doubtful. The definition of inherent hazards is set forth in AICPA (SOP) 81-1 (1983), as any condition that make otherwise reasonably dependable contract estimates doubtful. For interim accounting periods during contract performance, contract cost and amounts billed are debited and are reflected in the contractor's balance sheet as accounts receivable under the category construction contract billings. Because the CC method only accounts for cost of contract to date, the income statement does not reflect earned revenue, or estimated profit on the contract during each accounting period like the POC method (Halpin, 1985; Welsch, 1979; Callahan et al, 1993). Thus, as construction work a progress, the contractor accumulates contract cost but does not recognize contract revenue until the date of substantial completion. Therefore, the underlying concept of the CC method is that the recognition of income and hence tax liability on earned income is deferred until the project is 100 percent complete. As a result, unlike the POC method, the determination of project income is not predicated on reasonably certainable estimate of contract cost. Since contract income is deferred until the end of the project, tax liability on the income is likewise not incurred until the contract is finally completed by the contractor (Combs et al, 1984; Callan et al, 1993; Adrian, 1988).

Table 8 demonstrates the CC method and how contract cost, revenues, and gross profit are not recognized until the project is finally completed in the last accounting period. Table 9 displays the recording difference between the POC and the CC methods. The purposes of the table is to present income data and demonstrate how income tax liability is incurred year-to-year under the POC paradigm and how income tax liability is deferred until the end of the contract period under the CC method.

Table 8

Financial Statement

Aggie Construction Company Financial Statement Presentation - Completed Contract Method			
	1993 $(000's)	**1994 $(000's)**	**1995 $(000's)**
Income Statement			
Long-term Contract Revenue	----	----	$ 5,500
Costs of Construction	----	----	5,050
Gross Profit	----	----	$ 450
Balance Sheet (12/31)			
Current Assets:			
Accounts Receivable	$ 150	$ 800	
Inventories			
Construction in Progress	1,000		
Less: Billings	900		
Unbilled Contract Costs	$ 100		
Current liabilities:			
Billings ($4,300,000) in excess of costs and recognized profit ($4,264,750)		$ 384	

Table 9

Comparison of Financial Position

	PERCENTAGE-OF COMPLETION	**COMPLETED CONTRACT**
1993	$ 125,000	$ - 0 -
1994	199,000	- 0 -
1995	126,000	450,000

Legislative Change in Accounting Methods

The Tax Reform Act (TRA) of 1986 promulgated several significant changes in long-term construction contract accounting (Pirrong, 1987). The TRA '86 restrained the use of the CC method for tax accounting purposes. Moreover, the TRA '86 created Internal Revenue Code (IRC) section 460, which allows the contractor to choose only two methods of accounting for a long-term contract (Adler, 1989). Section 460 of IRC, under TRA '86, allows only the POC method or a hybrid derivative of that method entitled the percentage of completion - capitalized cost method (POC-CC). In addition to setting forth the use of only these two accounting methods, the TRA '86 specified that only the CTC method be used to calculate the POC for income tax liability for the construction firm (Wright, and Mazurkiewicz, 1987; Pirrong, 1987). Additionally, TRA '86 requires income tax liability to be reported utilizing a POC method schedule of 40 percent of the recognized contract revenues, while the remaining 60 percent balance of contract revenues may be reported using the normal method of recognizing revenue and gross profit for income tax purposes (generally the completed contract method - Tax Pointer, 1987; Hawkins, 1989).

The Revenue Act (RA) of 1987 promulgated additional percentage limitations on long-term contract accounting. Pronouncements of the RA '87 amended the TRA '86 60/40 percent split in revenue recognition to that of a 70/30 split schedule (Adler, 1989; Hawkins, 1989). Otherwise, RA '87 maintained the same accounting restraints laid down in the TRA '86. The Technical and Miscellaneous Revenue Act of 1988 (TAMRA) further modified the POC-CC method of '86 and '87. TAMRA '88 requires a contractor with sales greater than $10 million and contracts that last longer than two years to use a 90/10 percent split schedule for tax accounting purposes. Thus, 90 percent of the contract price must now be accounted for under the POC, or the POC-CC method, while the remaining 10 percent may be recorded under the CC method (Adler, 1989). Table 10, demonstrates the impact of TAMRA '88 has on revenue recognition for a long-term contract, and the accelerated tax consequence that results.

The ramifications of the TAMRA ‘88 accounting rules have essentially eliminated the CC method of tax accounting. Thus, the deferral of income recognition and, therefore, the recognition of the tax liability will be limited to 10 percent of the revenue generated by the contract. The tax schedule under TAMRA '88 displays how the POC 40 percent of revenues in 1993 must now be recorded and recognized at 90 percent of its earned value. The 90 percent of earned value is subsequently taxed at the 34 percent rate. The remaining 10 percent of the earned value is deferred until 1995, where at that time the income is recognized and taxed at the 34 percent rate. This similar tax liability is incurred and deferred similarly for the 1994 accounting period. Finally, the 10 percent income deferred in 1993, and 1994 is summated with the earned value recognized in 1995 and taxed at the appropriate rate in the period the contract is finally 100 percent complete.

TAMRA '88 will significantly impact on the construction industry in several areas of financial management. Most importantly will be the increased emphasis on cash flow management requirements. Owing to earlier recognition periods for gross profits and the inability to defer 90percent of the tax liability for a profit center, the contractor will have to provide for increased cash outflows to cover future income tax liability payments incurred in earlier periods of the contract while work is still in process. A second consideration is the management methodology associated with front-end loading. Management, when employing this technique, will certainly have to consider proper matching of revenues and expenses in each tax accounting period.

Table 10

Tax Calculation Using TAMRA '88

Facts:

Aggie Construction has a three-year contract to build an office building, with a starting date of April, 1993, and a completion date of October, 1995. Contract price is $5,500,000. Total contract cost is $5,000,000. Each year a percentage of general and administrative expenses are allocated to the contract.

Percentage of Completion Schedule

	1993 $(000's)	**1994 $(000's)**	**1995 $(000's)**
Contract Cost to Date	$ 2,200	$ 3,916	$ 5,050
Allocated G&A Expense	60	75	85
Estimated Total Contract Cost	4,000	4,050	4,050
Percentage Complete	$ 2,000	$ 3,916	$ 5,050
	5,000	5,050	5,050
	40%	77.5%	100%
Gross Profit	$ 200	$ 149	$ 101

Tax Schedule Based on Completed Contract Method

Contract Revenues	$ - - - -	$ - - - -	$ 5,500
Contract Cost to Date	- - - -	- - - -	5,050
Gross Profits	- - - -	- - - -	450
Less G&A Expenses	- - - -	- - - -	220
Taxable Income	- - - -	- - - -	$ 230
Tax Liability ($230,000 * 34%)			$ 78

Tax Schedule Based on TAMRA '88

	1993 $(000's)	**1994 $(000's)**	**1995 $(000's)**
Contract Cost to Date	$ 2,200	$ 3,916	$ 5,050
Allocated G&A Expense	60	75	85
Estimated Total Contract Cost	4,000	4,050	4,050
Percentage Complete	40%	77.5%	100%
Gross Profit	200	149	101
Less G&A Expense	60	75	85
Taxable Income	140	74	38
Tax Liability	(a) 43	(b) 23	(c) 13

(a) $ 140,000 * 90% * 34%
(b) $ 73,750 * 90% * 34%
(c) $ 37,650 * 34%

Where: (a)	= ($ 14,000 - $ 126,000):	$ 14,000
(b)	= ($ 73,750 - $ 66,375):	$ 7,743
(c)	= ($ 101,250 - $ 85,000):	$ 16,250

Conclusion

The Tax Reform Act of 1986 and the Technical and Miscellaneous Revenue Act of 1988 have significantly altered the time frame for when a contractor must recognize income for a long-term contract. In essence, the Internal Revenue no longer recognizes the completed contract method for income tax liability purposes. Therefore, the contractor must use the percentage-of-completion method for both financial presentation and tax reporting purposes. The ability of the contractor to defer recognition of income tax liability is restrained to 10 percent of the project contract amount that is not calculated under the percentage-of-completion method. Therefore, under the new tax law, a contractor will experience a greater tax burden in earlier accounting periods than otherwise would be the case vis-à-vis Tax Reform Act of 1986 income tax reporting methods for a long-term construction contract.

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Predictability of Adjudicated Liquidated Damage Clauses in Construction Contracts

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This article addresses the issue of whether courts in the United States demonstrate a trend in application preference for the intent test when ascertaining the validity of a liquidated damages clause in a construction contract. Judicial opinions, dating from 1853 to 1991, formed the population of study. Retrieval of archived judicial opinions are from official and unofficial legal reporters for the United States. Of the 223 selected appellate court cases, 175 met the population parameters. Data derived from these judicial opinions were statistically tested by: (a) the chi-square test statistic for a binomial one-way dimensional classification, and (b) the Stuart-Cox sign test for trend analysis of discrete data. Results of the chi-square test reveal that courts demonstrate a preferred pattern of movement away from applying the intent test when construing the validity of a liquidated damages clause. Based on the Stuart-Cox sign test, however, the current pattern of judicial application preference does not display the presence of a statistical trend for future application preference. Although the current application preference of the courts is in the direction *do not apply* the intent test to determine the validity of a liquidated damages clause, there is no presence of a statistical trend that would allow one to conclude that this is the preferred application of the judiciary in the future.

Key Words: Contracts, Liquidated Damages Clause, Penalty Clause, Non-excusable Delay

Purpose

The purpose of this article is to present the results of a study by Donald A. Jensen that investigated adjudicated court decisions in the United States that had at issue the legal validity of a liquidated damages clause incorporated in a construction contract between an owner and contractor. The original study sought to answer the question: whether courts of the United States demonstrate an application preference for the intent test when ascertaining the legal validity of a liquidated damages clause, and whether such preference, or lack of preference, displays a trend for future application. To this end, all published common law judicial opinions for construction contracts (from 1853 through to 1991) that questioned the validity of a liquidated damages provision between the owner and contractor were reviewed. In all judicial opinions, the linearity of contractual privity was between the owner and prime contractor. Two hundred and twenty-three (223) judicial opinions were retrieved from official and unofficial legal reporters for the United States. Of the 223 appellate court cases, 48 court cases were deleted from the study for noncompliance with the population parameters.

The analytical model for the research design was a non-experimental correlational study of historical data. The methodology employed was content analysis utilizing the statistical techniques utilized of: (a) the chi-square test statistic for a binomial one-way dimensional classification test, and (b) the Stuart-Cox sign test for trend analysis for a discrete nominal data set.

Introduction

The typical contract for a nonresidential construction project will contain a *liquidated damages clause* (Ward, 1985). In this application, the liquidated damages clause represents an attempt by the owner to preconfigure monetary damages in advance of a pre-defined breach (American Jurisprudence, 13, 1964; Restatement, Second, 1981). The pre-defined breach is the required contract time necessitated beyond the date of substantial completion that the contractor takes to complete construction. This additional time period is legally referred to as a *nonexcusable delay* (Arditi & Partel, 1989). By definition, a nonexcusable delay provides the owner with an opportunity to claim damages for that period of time in which it is unable to utilize the contracted for structure for its intended purposes (Jervis and Levin, 1988). Since this extended unexcusable time period precludes the owner from use of the structure, it is presupposed that the liquidated damages represents, monetarily, any actual inconvenience, lost production, lost rent, or lost profit suffered by the owner that results there from in the form of consequential damages (American Jurisprudence, 22, 1964; Cushman, 1990; Simon, 1989).

In order for a liquidated damages clause to be legally operable at law, the stipulated damages amount must be in accordance with the basilar principles of compensable damages (Restatement, Second, 1981). On this basis, the liquidated damages amount must be in agreement with the paradigmatic theory of compensable damages, and represent a reasonable approximation of damages that place the nonbreaching party in the same position had a breach not transpired. Thus, neither the intent, nor the purpose of a liquidated damages clause should be to exact contractual compulsion on the breaching party so as to promote continuance in contract performance. Moreover, should the court construe a liquidated damages clause in this manner, and then the clause is defined as a penalty provision and, hence ruled legally nugatory (Dunbar, 1959; McCormick, 1935).

A penalty clause, by definition, is a monetary sum inserted in a contract, not as a measure of approximating financial compensations for a pre-defined breach, but rather functions as financial castigation for noncontractual performance (American Jurisprudence, 13, 1964). The ideology of financial punishment has been operationally defined as in *terrorem* (Loyd, 1915; Geotz and Scott, 1977). *In terrorem* legally means in fright or alarm by way of threat (Black's Law Dictionary, 1979). Thus, a penalty clause seeks to prevent a promisor from breaching a contract by using financial punishment as a deterrent, thereby violating the compensatory paradigm of contract remedies because the punitive construct lacks justification on an economic basis (Calamari and Perrillo, 1987; Restatement, second, 1981). As a corollary then, the essential difference between a liquidated damages clause and that of a penalty clause is that the former attempts to place the nonbreaching party in the position that would have been experienced had a breach not transpired. The latter, however, attempts to force the breaching party to contractually perform by invoking contractual punishment in the form of a specified monetary amount that is significantly disproportional vis-à-vis the actual financial damage amount sustained by the breach (Sweet, 1972; Williston, 1957).

Determination of Liquidated Damages and Penalty Clauses

Given the purpose of the study, the logical question is: How do the courts determine the difference between a liquidated damages clause and a penalty clause? Kaplan (1977) establishes that the courts, when ascertaining the validity of a liquidated damages clause, apply a three-prong test that includes: (a) the intent test, (b) the difficulty test, and (c) the reasonable test. Although, these three tests provide measurement for ascertaining the validity of a liquidated damages clause, its application produces much controversy within the literature (Gantt and Breslauer, 1967).

The Intent Test

The test for intent is based on the *objective theory of assent*. Application of this test places importance on whether the parties intended to liquidate damages in advanced on the basis of the parties' acts and words (Farnsworth, 1990). The parties' actions are judged by the standard of reasonableness. The words of the parties are given their clear meaning by the courts when interpreting the contract language (Kaplan, 1977). Finally, the courts examine the circumstances surrounding the parties at the time of contract (Corbin, 1964). Thus, the intent test examines the actions, words, and circumstances of the contracting parties at the time of contract execution.

The Difficulty Test

When the courts attempt to ascertain the difficulty of calculating damages, great weight is placed upon the degree of uncertainty involved in the estimate (Corbin, 1964). The greater the degree of difficulty in correctly estimating the accuracy of likely future damages, the more valid the liquidated damages clause becomes in the eyes of the court. Conversely, the more certainable the actual damages are to estimate, the more likely the court will be to construe the agreed damages clause as a penalty provision (American Jurisprudence, 22, 1964). Prentice (1937) writes that the uncertainty test refers to how readily capable and improbable a calculation for compensable damages will be to ascertain. The greater the improbable nature of the damages is to make certain, the more favorably the court views such a covenant as a valid operable liquidated damages provision (Prentice, 1937; American Jurisprudence, 13, 1964).

The Reasonable Test

In general, if the agreed damages amount is deemed unreasonable in view of the actual damages suffered by the breach, the court will construe the *proviso* a penalty provision and rule same invalid (Corbin, 1964). The reasonable test measures the probable approximation of the uncertain compensatory damages likely to occur in the future (American Jurisprudence, 13, 1964). The operative words used by the judicature in its application of the reasonable rule are "reasonable forecast," or an "honest forecast" (Dunbar, 1959). Reasonableness further draws on the notion of disproportionality vis-à-vis the anticipated loss from the nonperformance. The larger the fixed sum is in relation to the anticipated loss resulting from the breach, the more likely the courts will rule the clause a penalty provision and, thus, unenforceable (Koezuka, 1990; Prentice, 1937).

Validity of Liquidated Damages Clauses

A review of the legal literature suggests that in determining the validity of a liquidated damages clause, the courts are consistently inconsistent in applying each test in each independent case. Mueller (1952) and MacNeil (1962) espouse that the case law is fraught with variant applications of the three-prong test and, therefore, court opinions are nebulous and ambiguous regarding the appropriate test or tests to be applied that distinguishes between a valid liquidated damages clause, and one that is determined to be a penalty provision. It is suggested that the confusion found within the court opinions is a function of the courts being in disagreement over which tests are the appropriate test of law to apply when construing the validity of a liquidated damages agreement Murray (1974). Based upon the literature, one might conclude that the courts do not demonstrate any consistency, or application preference in applying the three test that formulate a decision criteria when determining the validity of a liquidated damages clause.

The prime contractor often contends that a liquidated damages clause is in actuality a penalty provision (Ward, 1985). Thus, the contractor sues the owner for the balance on account for monies held in retainage and, or for relief of the liquidated damages in general. Owing to the supposed confusion by the courts in ascertaining the validity of a liquidated damages clause, the managerial problem encountered by the contractor is whether or not to pursue the legality of it. The management decision to challenge the validity of such a clause creates a business risk decision that may possibly threaten the financial position of the firm (Hardie, 1981). Within this risk decision is the inherent legal and managerial question of whether or not the construction organization should challenge the validity of a liquidated damages clause by initiating formal legal proceedings in view of the supposed uncertain preference of the courts in this area of contract law. The managerial risk is the uncertainty of receiving a disfavorable court award as a result of the supposed inconsistencies in court decisions and, thereby incur further financial loss. In order to make informed risk decisions and, thereby mitigate a degree of uncertainty, good management decision requires probabilistic projections on the certainty of future outcomes. Despite this pervasive requirement by management, currently, there exists a paucity of literature regarding studies that apply statistical analyses to determine specifically the application preference of the courts relative to this test prong (Sweet, 1972). Although the literature concerning liquidated damages is extensive, erudites on the subject appear satisfied with broad generalities encompassing statements about the extreme uncertainties in this area of law by placing reliance in interpretative qualitative analysis of past judicial decisions. Although such a prior knowledge is meritorious, it unequivocally lacks scientific investigation. Therefore, the purpose of this research study is to provide management of the construction industry with a quantitative study that empirically measures the application preference of the courts for the intent test when ascertaining and construing the validity of a liquidated damages clause in a construction contract.

A Closer Look at the Intent Test

The intent test criterion places importance on the measurement of whether or not the parties intended to liquidate damages in advance of the contractual breach (Kaplan, 1977). The court, using the canons of interpretation, investigate the parties intent on the basis of its expression in words and the circumstances surrounding the parties at the time of contract (McCormick, 1935; Corbin, 1964). The application preference of the intent test by the courts to ascertain the validity of a liquidated damages clause is an issue that divides learned scholars on the topic into two groups. One group of writers adheres to the belief that the intent test has applied preference by the courts and is a decisive test in determining the validity of a liquidated damages clause. For example, it is postulated that the intent test is the preferred measure of the courts in testing enforceability of an agreed damages clause Mueller (1952). MacNeil (1962), argues similarly that the intent test is one of the critical deciding variables in the court's analysis. Peckar (1972) comments that the intentions of the contracting parties are critical in the determination of enforcement of the clause. Peckar also comports that it is the application of the intent test that ascertains whether the stipulated damages clause operates as a measure of compensatory relief, or whether it operates as an in terrorem provision in the contract. Finally, Ward (1985), also acknowledges the value of the intent test by maintaining, that same is one of the important elements that the courts discuss in testing the validity of a liquidated damages clause.

On the other hand, there are authors that believe the intent test is not a preferred test, and that it is not essential in ascertaining validity of the clause, thereby maintaining that currently the test is of little significance to the courts. Dunbar (1959) supports this point by maintaining that the courts pay "... lip service to the intention of the parties...", and that the courts apply the test of reasonableness and difficulty. Murry (1974) comments that the intentions of the parties is immaterial and that court opinions give it little consequence. Similarly, Kaplan (1977) elucidates that earlier court opinions determined the validity of a liquidated damages clause solely on the basis of the intent test, however, currently the contemporary trend is for the courts to virtually ignore the test. Two other authors, Calcamari and Perillo (1987), underscore the importance of the intent test by stating that the courts give the test "little moment" and, thus it is of minute import in the decision making process. Finally, Farnsworth (1990) likewise maintains, although the courts refer to the intention of contracting parties, the reference to the intent test is less frequent and of less weighted importance in relation to the difficulty and reasonable tests.

Data Analysis and Results

To test the hypothesis: the courts demonstrate no application preference for the intent test when ascertaining the validity of a liquidated damages clause, and whether there exist the presence of a trend a binomial univariate dimensional classification was employed. The univariate dimension variable is the intent test. The categorical levels, or dichotomous classification, for the dimension variable are: (a) not applied, and (b) applied.

Tables 1,2, and 3, shown below, provide the tabulations and calculations for the data summarized in Table 4. For the one-way classification matrix displayed in Table 4, a chi-square statistic equaling 7.00 was calculated. A critical chi-square with one degree of freedom using a 0.05

criterion level of significance equaled 3.84. Because the chi-square statistic at 7.00 is numerically larger than the chi-square critical at 3.34, the null hypothesis of no significant difference in application preference at a 0.05 level of significance is rejected.

Table 1

Frequency Distribution for the Intent Test: 10-Year Intervals

Chronological Time Intervals															
Intent Test	1858 1867	1868 1877	1878 1887	1888 1897	1898 1907	1908 1917	1918 1927	1928 1937	1938 1947	1948 1957	1958 1967	1968 1977	1978 1987	1988 1991	Totals
Case Count For Interval	1	1	3	11	22	25	7	4	8	10	12	20	33	18	175
Test Not Applied	1	1	1	2	12	12	4	1	5	3	8	16	24	15	105
Test Applied	0	0	2	9	10	13	3	3	3	7	4	4	9	3	70
Category					%										
Intent test not applied: 105 + 175 =					60.00										
Intent test applied: 70 + 175 =					40.00										

Table 2

Percent Application Preference for Intent Test

Interval Number	Time Interval	Case Count for Interval	Test Applied	% Test Applied	Test Not Applied	% Test Not Applied
1	1858 - 1867	1	0	0	1	100.0
2	1868 - 1877	1	0	0	1	100.0
3	1878 - 1887	3	2	67.0	1	33.0
4	1888 - 1897	11	9	81.0	2	18.0
5	1898 - 1907	22	10	45.0	12	48.0
6	1908 - 1917	25	13	52.0	12	48.0
7	1918 - 1927	7	3	43.0	4	57.0
8	1928 - 1937	4	3	75.0	1	25.0
9	1938 - 1947	8	3	38.0	5	62.0
10	1948 - 1957	10	7	70.0	3	30.0
11	1958 - 1967	12	4	33.0	8	67.0
12	1968 - 1977	20	4	20.0	16	80.0
13	1978 - 1987	33	9	27.0	24	73.0
14	1988 - 1991	18	3	17.0	15	83.0
	TOTALS	175	70	40.0	105	60.0

Table 3

Chi-Square Statistical Test: Application Preference of Courts for the Intent Test

Intent Test	fo	fe	fo - fe	(fo - fe)2	(fo - fe)2 / fe
Not Applied	105	87.50	17.50	306.25	3.50
Applied	70	87.50	-17.50	306.25	3.50
TOTALS	175	175.0			

fe = 175/2 = 87.5

X^2 statistic = 3.50 + 3.50 = 7.00

X^2 critical = 3.84; df = 2 - 1 = 1; significance $p < .05$

X^2 statistic = 7.0 > X2 table = 3.84 reject null hypothesis

Table 4

Chi-Square Statistical Test: Application Preference of Courts for the Intent Test

Intent Test	fo	fe	% D	fo - fe	(fo - fe)2	fo - fe)2 / fe	% split
Not Applied	105	87.50	20	17.50	306.25	3.5	60
Applied	70	87.50	20	-17.50	306.25	3.5	40
TOTALS	175	175.00				7.00	100

Note: The expected frequency of 87.50 indicates a 50/50 split in court applications preference. A 50% split outcome represents no application preference by the courts to apply the intent test.

Rejection of the null hypothesis results from the numerical deviation equal to 20%, which is the numerical difference between the observed frequency (f_o) and the expected frequency (f_e). This 20% deviation represents nonrandom disagreement between the actual data retrieved by the descriptive survey (f_o) versus the expected probabilistic frequency (f_e) proffered by the hypothesis. These results indicate that the courts demonstrate a preferred patterned movement away from the hypothesized 50% split of no application preference for the intent test in the amount equal to the nonrandom deviation of 20%. Table 4, column titled *% split*, displays the actual percent data split to further support this finding. Given the 175 court cases observed 60%, or 105 cases, of the courts did not apply the intent test when ascertaining the validity of a liquidated damages clauses. While 40%, or in 70 cases, the courts did apply the intent test to determine the validity of a liquidated damages clauses. This outcome represents a descriptive statistical 60/40 split in application preference by the United States courts. These results indicate that the courts have historically, across the 1853 to 1991 time frame, demonstrated a patterned application preference of not applying the dimension variable intent test when attempting to ascertain the validity of a liquidated damages clause. Figures 1 and 2 graphically present the patterned application preference of the courts.

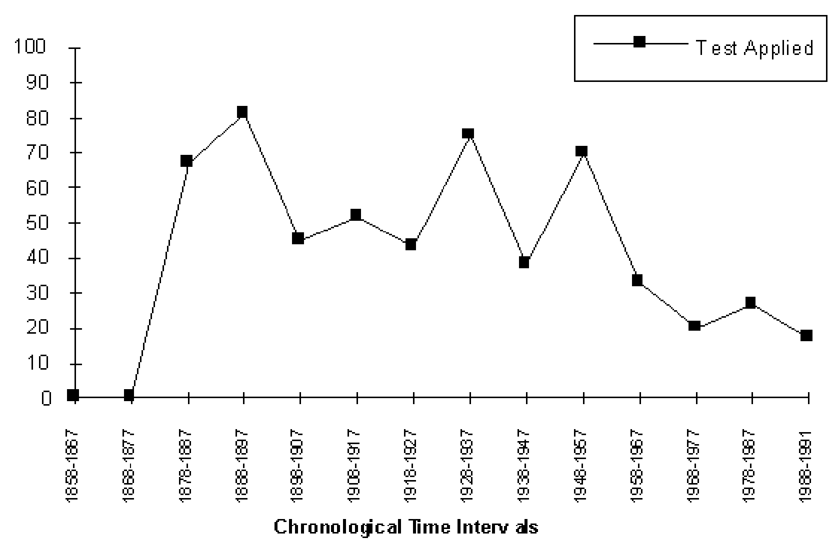

Figure 1. Application Preference for Intent Test.

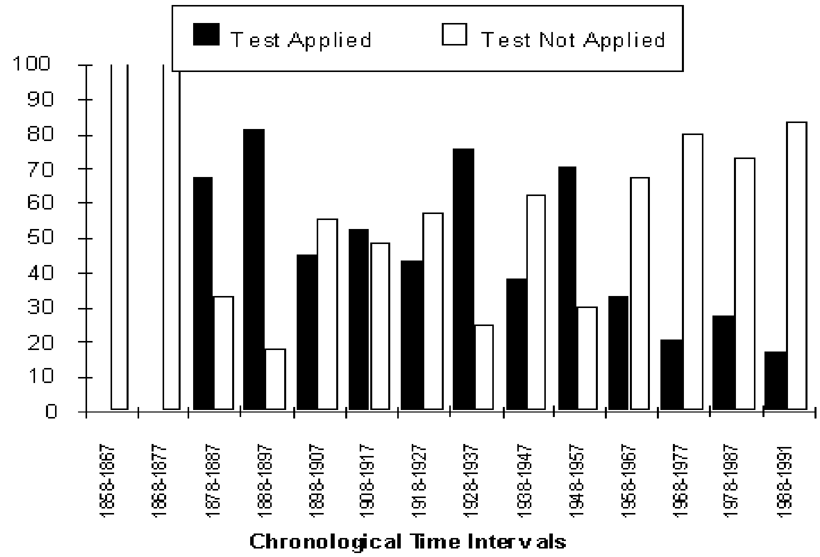

Figure 2. Applied Versus not Applied.

To test the second part of the hypothesis, a Stuart-Cox sign test for trend analysis was conducted for the time interval 1928 to 1991. Tables 5 and 6, shown below, display the data tabulations, calculations, and the stated null hypothesis for this particular analysis. For the data contained in Table 4, and for Figures 1 and 2, at $P(K \leq 5|5, 0.50) = 0.0624$ with significance at $a/2 = 0.025$, the null hypothesis contained in Table 6 cannot be rejected. It is therefore concluded, for the time frame 1928 to 1991, the data demonstrates that the United States court opinions display no presence of a trend for the current application preference in the categorical level *not apply* intent test.

Table 5

Data Compilation for Trend Analysis for the Application Preference of the Intent Test from 1858 to 1991

Time Interval	**Xi % Cases Test Applied**	**Time Interval**	**Yi % Cases Test Applied**	**Xi - Yi Sign Test**
1858 - 1862	0.00	1928 - 1932	66.67	-
1863 - 1867	0.00	1933 - 1937	100.00	-
1868 - 1872	0.00	1938 - 1942	33.33	-
1873 - 1877	0.00	1943 - 1947	40.00	-
1878 - 1882	0.00	1948 - 1952	50.00	-
1883 - 1887	66.67	1953 - 1957	83.33	-
1888 - 1892	75.00	1958 - 1962	0.00	+
1893 - 1897	85.71	1963 - 1967	50.00	+
1898 - 1902	40.00	1968 - 1972	12.50	+
1903 - 1907	50.00	1973 - 1977	25.00	+
1908 - 1912	38.46	1978 - 1982	40.00	-
1913 - 1917	66.67	1983 - 1987	0.00	+
1918 - 1922	40.00	1988 - 1991	16.67	+

Table 6

Data Calculation for Tend Analysis for Application Preference of the Intent Test from 1928 to 1991

Time Interval	**Xi % Cases Test Applied**	**Time Interval**	**Yi % Cases Test Applied**	**Xi – Yi Sign Test**
1928 - 1932	66.67	1963 - 1967	50.00	+
1933 - 1937	100.00	1968 - 1972	12.50	+
1938 - 1942	33.33	1973 - 1977	25.00	+
1943 - 1947	40.00	1978 - 1982	40.00	0
1948 - 1952	50.00	1983 - 1987	0.00	+
1953 - 1957	83.33	1988 - 1991	16.67	+

Statistical Hypothesis:

Ho: There is no trend present in the data

Ha : There is either an upward trend or downward trend

n¢ = 27 n = 5 K = 5 positive differences a/2 = 0.25

Test Statistic

P (K £ 5/5, 0.50) = 0.0312 * 2 = 0.0624 P = 0.0624 > a/2 = 0.025

Decision: Cannot reject null hypothesis; there is no trend present in the data

Upon closer inspection of Tables 1 and 2, and Figures 1 and 2, the outcome, no presence of a trend, is explained by the downward and upward movements for the time frame 1927 to 1967. Starting in 1937 and ending in 1947, the intent test curve moves downward 49.33%. For the time frame 1947 to 1957 an upward movement of 84.21% is observed. Finally, from 1957 to 1967 the intent test curve moves downward by 52.86%. These upward and downward variations create a mathematical smoothing effect in the application preference curve *do not apply* intent test, whereby the slope of the line is not significantly different from zero. This result indicates that the data, court opinions, displays no trend in the current application preference, *do not apply* intent test. Similar observations and explanations exist for the combined time interval 1967 to 1991. Consequently, because the percent variations from interval period to interval period are approximately equal in numerical magnitude, any cyclical upward or downward movement negates the prior periods upward or downward advancement. Although the courts demonstrate a significant statistical application preference for the classification category *not applied* intent test across the 1853-1991 time period, starting from the 1928 interval to present there is no presence of a statistical trend that would indicate that the classification category *not applied* for the dimension variable intent test will be the predictable application preference of the courts in the future.

One possible explanation for the upward and downward cyclical movement of the data could be based on the observations that the states of California, New York, and Illinois (plus the corresponding Federal circuits employing those state's laws,) are the most inconsistent in applying or not applying the intent test on a consistent basis. It was also observed that Missouri has applied the intent test with a degree of inconsistency. Other states, such as Tennessee and Alabama, appear to be equally (50/50) divided in application. Massachusetts has twice as many cases applying the intent test as it does not applying it, while Florida has demonstrated consistency in not applying the intent test.

Conclusions and Recommendations

The importance, and the intention, of this research study was to provide managers of the construction industry with a quantitative research study that empirically measures the application preference of the courts for the intent test. The study results show that the application preference of the courts for the intent test is in the direction of *do not apply*. Thus, at present, the intent test is not a measure utilized by the courts in the enforceability question of a liquidated damages clause.

The test for presence of a trend, however, resulted in no presence. Thus, although the present application preference is *not apply the intent test*, there exists no presence of a trend. This suggests that one cannot rely on the current application preference of the courts to continue with the current application preference in the future.

It is recommended that further studies be conducted to ascertain which states have contributed significantly to the cyclical nature of the data, and attempt to explain the political, economical, and social justification for such court movement.

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Benchmarking Project Success

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Measuring project success is elusive. Most previous studies focused strictly on either a qualitative or quantitative measurement of success. This paper will present a powerful measurement system that combines the two. The system was developed through the study of 53 capital improvement projects. Data were gathered by way of project historical records as well as interviews with the major project participants. Project success variables were identified. Subsequently, meaningful measures of the variables were developed and the most probable data source was selected. Data analysis is in the form of index construction and validation. The success index includes the following objective measures: cost performances, schedule performance, plant utilization, and design capacity obtained after six months of operation. Variable weights were constructed using subjective data obtained through 131 interviews. With the combination of objective and subjective measures, a potent benchmark for project success was developed.

Key Words: Project Success, Success Index, Measuring Success

Introduction

The measurement of project success is an immense task. A comprehensive review of current literature identified many studies that have tried such a measurement. Several researchers have concluded that measuring project success in solely objective terms is an impossible task (de Wit 1986; Morris 1986; Stuekanbruek 1986). There are many reasons for the complexity of measurement of results. These include: project objectives that change ova time, the multitude of project participants and stakeholders and their different objectives, and the subjective nature of many desirable project outcomes (deWit 1986). This study defines a method for benchmarking project success that combines objective, historical data with subjective project data. First, project success measures and data sources were identified. Data were then collected from 53 industrial projects. Subsequent statistical analysis of the objective data and qualitative analysis of the subjective data resulted in a success benchmark.

A research team under the guidance of the Construction Industry Institute (CII) accomplished this research. CII is a consortium of large owner, engineering and construction firms. It was founded in 1983 to conduct research in the engineering and construction arena. Currently, it has 90 members and is considered one of the premier research organizations in the world dealing with project management issues. The specific research team that charged with defining project success consisted of approximately 16 industry personnel, split among owner and contractor personnel, along with an academic researcher.

Methodology

Because no clear definition of success existed for use in this study, the first step of the research team was to conceptualize success. Four initial broad categories of success were produced: business, project management, operations and social. These four concepts were further defined by nine categories. Business success consists of the sub-categories of marketing and financial success; project success consists of three sub categories: quality management consists of project controls and ease of E/P/C. Success in the area of operations consists of the sub-categories of construction/ operations transition, operating characteristics and maintenance. Lastly, social success is a category unto itself.

After determining the variable measures, the data sources with the highest probability of providing the best information were selected. Success variables are shown in column one of Appendix A. Data were available from one of four sources: business manager (BU) shown in column two, project manager (PM) shown in column 3, operations manager (OP) shown in column 4 or Project historical data (Historical) shown in column S. Data from the project representatives were collected through telephone interviews, whereas historical data were gathered using a project questionnaire. Categories of variables and data sources are indicated in Appendix A with an asterisk (Gibson, Kaczmarowki and Lore, 1993). As can be seen, multiple data sources were used wherever possible.

Variable Measurement

After the variables were defined and data sources identified, the specific measure of the variable was determined. This was a critical stage in the development process.
Only through examination of meaningful measures can any fruitful research results be discovered. Some general guidelines for a good measure, or metric, come from "The Metrics Handbook" developed by the U. S Air Force (1991). As stated in the handbook, "For a measure to be meaningful, it must present data that allow us to take action. It must be customer oriented and support the meeting of organizational goals and objectives. Metrics foster process understanding and motivate action to continually improve the way we do business." The success measures used in this study are shown in Appendix B and are detailed by the variables and measures in column 1, the objective measure in column 2, and the subjective measure in column 3.

Data Sample

In order to obtain data, we contacted all Construction industry Institute owner-members for possible participation. Twenty-two CII owner-member companies responded Table 1 shows how many of each type of company, by industry, responded to the survey. Column 1 exhibits the company type, while column 2 presents the number of respondents corresponding to each project type. Even though they represent different market sectors, all companies have a common need to build capital improvement projects to meet product and regulatory needs.

From the 22 companies, 62 projects were selected for study. Data on 53 of the projects was sufficient to evaluate success. These 53 projects represent 19 owner companies. Characteristics of the sample 53 projects are shown in Figures 1, 2, and 3. Figure 1 shows that the majority of the projects, 24 (48 percent), are retrofit/expansions, with 18 (34 percent) being co-located and 11 (20 percent) being grassroots projects.

Table 1

Company Type

Company Type	Number
Petro-Chemical	6
Chemical	5
Pulp and Paper	2
Power	2
Consumer Products	2
Petroleum	2
Pharmaceutical	1
Communications	1
Government	1

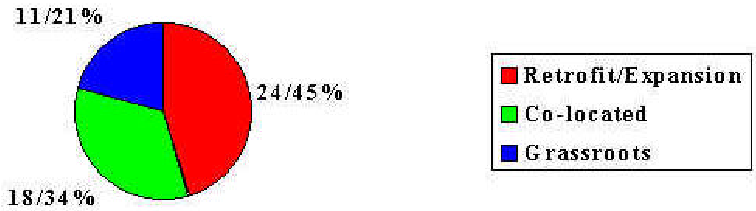

Figure 1. Sample construction type.

Figure 2 depicts the project types: 32 (62 percent), are chemical, petro-chemical or petroleum refinery, with power and consumer products making up 15 (28 percent) of the sample.

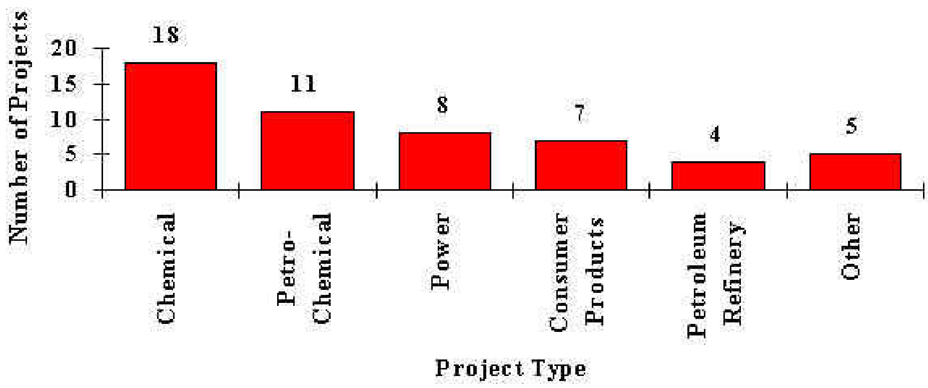

Figure 2. Sample project type.

Figure 3 shows the distribution according to project size. As shown in Figure 3, twenty-six (49 percent) of the projects had authorization budgets of $25 million or less with 13 (24 percent) in the $25 to $50 million dollar range and the remaining 14 (27%) in the range between $50 to $350 million.

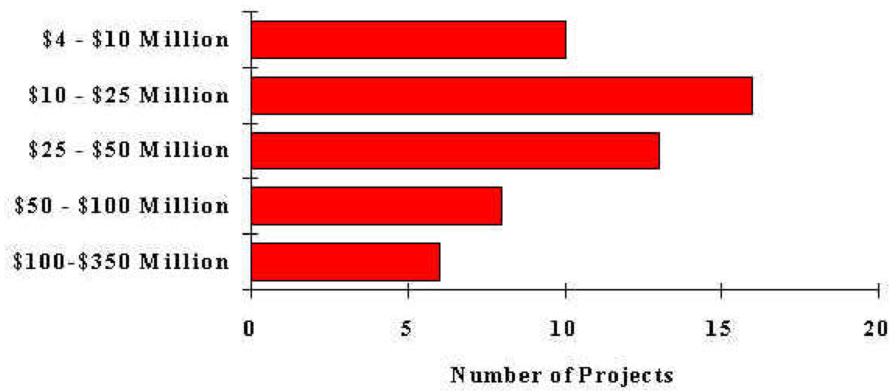

Figure 3. Project size.

Development of the Success Index

The success index was developed by first identifying the individual variables from Appendix A that qualified for inclusion. This was done through testing each variable by using a process that requires each variable step-wise insertion into a statistical procedure. This test measures the reliability and validity of an index and its value as a composite gauge of the concept being measured. The resulting variables forming the index measuring project success are listed below with their definitions and standards of measurement.

Budget Achievement

Budget achievement is defined as adherence to the authorization budget. It is measured by the percent of deviation from the authorization budget to the final project cost.

Schedule Achievement

Schedule achievement is defined as of deviation from the authorization schedule by the actual project schedule.

Design Capacity

Design capacity is defined as the nominal output rate (i. e. tons per year, barrels per day, kilowatts, etc.) of the facility which is used during engineering and design-to-size equipment and mechanical and electrical systems. The measurement used was the percent of planned at authorization attained after six months of operation.

Plant Utilization

Plant utilization is defined as the percentage of days in a year that the plant actually produces product. The unit of measurement is the same as for design capacity: the percent of planned at authorization attained after six months of operation.

Variable Weights

To give the variables weights, a qualitative analysis of the interview data was performed. The exact, open-ended question asked of the project players was "What are your main reasons for your assessment of the project's level of success" One hundred and thirty-one responses were obtained and analyzed. They were categorized into factors using qualitative analysis techniques. This analysis revealed the specific variables and categories that participants considered being significant to success and their relative level of importance (Tortora 1993).

Project controls and operating characteristics were identified as the most important areas of success by the interviewees. An analysis of the responses revealed the index variables to have the weights shown in Table 2. The measurement category is shown in column 1 with its weight in column 4.

Table 2

Success Variable Weights

Success Category	Variable	Variable Weight	Category Weight
Project Success			0.60
	Budget Achievement	0.55	
	Schedule Achievement	0.45	
Total Variable Weight		1.00	
Operating Success			0.40
	Design Capacity Attained	0.70	
	Plant Utilization	0.30	
Total Variable Weight		1.00	
Total Category Weight			1.00

Each index variable weight is shown in column 2, with corresponding weights in column 3. The columns depicting weights (2 and 3) both add up to 100%. It should be recognized that this step, in itself, represents a unique contribution to success measurement. The index combines objective historical data with relevant and timely subjective criteria. This resulting formula, equation (1), was used to calculate the success index, which represents an industry benchmark for project success.

Success Index Value = 0 .60 * (O.55 Budget Achievement Value + 0.45 Schedule Achievement Value) + 0.40 * (0.70 Design Capacity Attained Value + 0.30 Plant Utilization Attained Value) Index values for success were calculated f or each sample project. A frequency distribution of these values indicated that the maximum value was 5.0 and the minimum was 1.0. The average value was 3.2 and median value was 3.1. The standard deviation was 1.0. Since the lowest score possible was 1.0 and the highest 5.0, these statistics show a fairly even distribution.

Index Validation

In validating the success index, the hypothesis that there is a significant, positive correlation between a project's level of success, as defined by the success index, and whether or not the project exceeded, met, or fell short of its overall financial go also was tested. Using the k-independence test for significance, the relationship between the success index values and overall financial success was positive and significant at the 0.07 level. Therefore, as the success index value increases so does the likelihood that the project will meet or exceed its financial goals. This is an important finding because it tells us that by achieving the four performance measures comprising the success index, a project is very likely to exceed or meet its overall business goals, the bottom line. The fact at there was a significant relationship between the success index and achievement of overall financial goals, another success measure, is a good indicator that the success index is valid.

Summary

This research produced a composite measure, which can be considered an industry benchmark, for the level of success attained for a capital improvement project (see Formula 1).
The measure includes four baseline performance measures, which are shown in Table 3. Column 1 denotes each success variable, while column 2 provides the specific measure.

Table 3

Success Baseline Measures

Variable	**Measure**
Cost Performance	Percent Deviation from Authorization
Schedule Performance	Percent Deviation from Authorization
Design Capacity Attained	Percent of Planned Attained
Plant Utilization	Percent of Planned Attained

This research reveals that the resulting success of a capital construction project can be measured comprehensively. It uniquely combines factual data along with appropriate subjective opinion data to produce an industry benchmark. By using this measurement system a company can gauge its performance, and determine its weak areas and improve them, promoting continual improvement of performance and an increased competitive advantage.

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Appendix A

Sources of Success Data

Variables	BU	PM	OP	Historical
BUSINESS SUCCESS				
Capture/Maintain Market Share	*			
Enhance Future Position	*			
Gain Competitive Advantage	*			
Financial Authorization Objectives	*			*
PROJECT SUCCESS				
Owner Cost				*
Owner Procured Equip/Material				*
Engineering Design Cost				*
Construction Cost				*
Commissioning and Turnover Cost				*
Start Up Costs				*
Teamwork Effort	*	*	*	
Customer Satisfaction	*	*	*	
Project Personnel Turnover		*		
Professional Performance		*		
Guidance From Management	*	*		
Rework		*		
Extent of Punchlists		*	*	
Budget Achievement	*	*		*
Schedule Achievement	*	*		*
Change Management		*		
Number/Magnitude of Changes		*		*
Effective Communications	*	*		
Risk Management		*		
Basis of Design		*		
Scope Definition		*		
Execution Strategy		*		
Constructability		*		
SOCIAL SUCCESS				
Achieves Legal & Regulatory Compliance	*	*	*	*
Labor Relations	*	*	*	
Safety and Health	*	*	*	*
Craft Labor Turnover		*		
Craft Labor Absenteeism		*		
Equal Employment Opportunity	*	*		*
Environmental	*	*	*	*
Community Relations	*	*	*	*
Noise		*	*	

Education/Training	*		*	
OPERATION SUCCESS				
Ease of Turnover		*	*	
Ease of Startup		*	*	
Spare Parts Availability		*	*	
Operator Training		*	*	
Equipment Documentation Availability		*	*	
Ease of Operation	*	*	*	
Availability	*	*	*	*
Flexibility	*		*	
Production Quality	*		*	*
Performance (cost to manufacture)	*	*	*	*
Plant Utilization				*
Design Capacity	*		*	*
Unanticipated Retrofits			*	*
Maintainability			*	*

Appendix B

Measure of Success Variables

	Measure	
Variables	**Objective**	**Subjective**
BUSINESS SUCCESS		
Capture/Maintain Market Share		Objectives Achieved
Enhance Future Position		Objectives Achieved
Gain Competitive Advantage		Objectives Achieved
Financial Authorization Objectives	Objectives Achieved	Objectives Achieved
PROJECT SUCCESS		
Owner Costa	Deviation from Authorization	
Owner Procured Equip/Material	Deviation from Authorization	
Engineering Design Cost	Deviation from Authorization	
Construction Cost	Deviation from Authorization	
Commissioning and Turnover Cost	Deviation from Authorization	
Start Up Costs	Deviation from Authorization	
Teamwork Effort		Participation
Customer Satisfaction		Needs were Satisfied
Project Personnel Turnover		Frequency of Change
Professional Performance		Performance Quality
Guidance From Management		Quality of Guidance
Rework		Amount
Extent of Punchlists		Amount
Budget Achievement	Deviation from Authorization	Objectives Achieved
Schedule Achievement	Deviation from Authorization	Objectives Achieved
Change Management		Quality of Management
Number/Magnitude of Changes	Percent of Total Cost	Magnitude
Effective Communications		Communication Level
Risk Management		Project Impact
Basis of Design		Success Contribution
Scope Definition		Smooth Execution
Execution Strategy		Actual v. Planned
Constructability		Use of
SOCIAL SUCCESS		
Legal & Regulatory Compliance	Any Unanticipated Encountered	Requirements Achieved
Labor Relations		Quality of Relations
Safety and Health	OSHA Recordables	Goals Achieved
Craft Labor Turnover		Turnover Rate
Craft Labor Absenteeism		Frequency
Equal Employment Opportunity	Percent of Target Achieved	Goals Achieved
Environmental	Percent of Attainment of Goals	Goals Met
Community Relations	Percent of Attainment of Goals	Goals Met

Noise		Goals Met
Education/Training		Goals Met
OPERATION SUCCESS		
Ease of Turnover		Smooth Turnover
Ease of Startup		Phase Well Executed
Spare Parts Availability		Available as Needed
Operator Training		Level Adequate
Equipment Documentation Availability		Available as Needed
Ease of Operation		Goals Met
Availability	Percent of Planned Attained	Goals Met
Flexibility		Goals Met
Production Quality	Percent Requirements Attained	Goals Met
Performance (cost to manufacture)	Percent of Planned Attained	Goals Met
Plant Utilization	Percent of Planned Obtained	Goals Met
Design Capacity	Percent of Planned Attained	Goals Met
Unanticipated Retrofits	Yes/No; Cost	
Maintainability	Percent Obtained	

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