Management's Perception of Key Performance Indicators for Construction

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Abstract: There is a great need in the construction industry for identifying a set of common indicators to be used by construction executive and project managers in measuring construction performance at the project level. The focus of this research was to collect management perceptions of the key performance indicators currently utilized in the construction industry. Both quantitative performance indicators and qualitative performance indicators are represented. A literature search was used to generate the initial set of perceived key performance indicators, which were administered to the construction industry via a survey. A statistical analysis of the collected survey responses provided information for the identification of a common set of perceived Key Performance Indicators (KPIs) by construction sector, management level, and experience level. Correlations were performed for both the quantitative and qualitative indicators to determine which type of indicator is used most extensively. Basic statistical analyses and frequency distributions provided evidence in support of some of the hypotheses of the research. The results of the survey data analysis support the hypothesis that KPIs vary according to management's perspective. Further analysis displayed a substantial difference between construction executive and project management's perceptions. However, six indicators were reported as being most useful by every segment of the construction industry involved in this study. The correlation between quantitative indicators and qualitative indicators proved to be inconclusive.

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Introduction

What is a Key Performance Indicator? Key Performance Indicators (KPIs) are compilations of data measures used to assess the performance of a construction operation. They are the methods management uses to evaluate employee performance of a particular task. These evaluations typically compare the actual and estimated performance in terms of effectiveness, efficiency, and quality in terms of both workmanship and product.

Generalized models exist for implementing and monitoring construction activities, but they fail to identify which indicators will accurately portray the changes in performance. Instead of reporting and disseminating every piece of information gathered on the job, a more simplified method should be used to gather only that data which directly predicts performance for the task to be measured.

In order to measure performance or calculate the effects of any given change on the construction process, one must first determine the appropriate Key Performance Indicators (KPIs) to focus on to measure its impact. Performance indicators can be defined by either the quantitative results of a construction process, i.e., $/unit, or by qualitative measures such as worker behavior on the job. Accurate analysis of construction performance can be attained only after the key indicators are determined and monitored.

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Objectives and Limitations

The objective of this research was to collect and analyze data that will help in the determination of perceived Key Performance Indicators (KPIs) for the construction industry at the construction executive and project management level. The KPIs identified may subsequently be used by construction executives and project managers both to monitor productivity and to evaluate performance. Data were obtained through a construction industry survey. Through statistical analyses, a set of Key Performance Indicators (KPI) were generated based on the different perceptions surveyed from both the executive and project levels of management. The areas focused on in this study are:

1. Commonly used quantitative performance indicators
2. Commonly used qualitative performance indicators
3. Delineation of the use of Key Performance Indicators by
   - Level of management
   - Level of self-performed work
   - Level of annual volume
   - Level of respondent's years of experience

The scope of this study did not include corporate level performance, nor did it attempt to evaluate the effectiveness of these performance measures.

Literature Review

The literature review of construction industry publications is divided into three sections. The first section of the literature review begins with a brief background on productivity and performance as they are used for this research. In the second section the focus

J. Constr. Eng. Manage., 2003, 129(2): 142-151

is to define and discuss the quantitative indicators used in the survey. The final section is devoted to defining the qualitative performance indicators as they pertain to this research.

Productivity/Performance Measurement

When assessing the impact of a given change in the construction process, one generally refers to the results as a change in productivity for the task being measured. A classical definition of productivity is a comparison of the output of a production process to its corresponding input, i.e., the output to input ratio. The construction industry commonly tracks this change in progress in terms of work units completely attained during a given period of time and the associated costs in terms of man-hours or dollars (Thomas and Mathews 1996).

However, productivity measurement and performance evaluation are two separate management functions. Productivity measurement involves the collection of information about various activities—specifically, work in place and the corresponding work-hours—over a given period of time. Overall performance evaluation involves a more comprehensive analysis of these same factors; hence, productivity is just one part of performance. Work-hours, quantities, and productivity are evaluated against the planned or baseline values used in project estimates (Thomas and Kramer 1988). Current performance is often measured against historical data or planned productivity to gain an overall sense of effectiveness.

In order to accurately identify the KPIs associated with the construction process, a baseline must first be determined. A historical baseline defines an average of past performance. Knowing past performance gives a reference point to benchmark against and to measure future performance (Alfeld 1988). A baseline can be compilations of years of historical data collected on previous projects or a quick measurement of current production prior to initiating a change for improvement. Oftentimes, any variation from the baseline (expected) performance level is an indication of a variance in performance. Variances can be either positive or negative and should bring about a cause for further management interpretation to determine root causes.

Quantitative Performance Indicators

The most commonly accepted performance indicators are those that can be physically measured by dollars, units, or man-hours. Like any other form of business, construction companies look first to the areas which show a change in the amount of revenue generated. Without a measurable improvement in terms of a cost reduction or a quantifiable increase in productivity, most managers will consider the change a failure. A review of the definitions provided in the literature of these quantitative types of measurements is therefore warranted.

Quantitative units of measurement should remain simple, easy to gather, and easy to apply, while not placing a heavy burden on field personnel. In most cases, the same units used in the estimating/costing system can be used in the productivity measurement system as well:

- **Units/MH:** The Units/MH reporting method is one of the two basic quantitative reporting approaches most commonly found in the construction industry. This method measures the number of completed units put in place per individual man-hour of work (Thomas and Mathews 1986; Halligan et al. 1994). This method takes little time to implement and gather information and can be used on any basic task or activity.
- **$/Unit:** The $/Unit performance indicator is the second of the basic quantitative reporting methods. The definition is simply the dollar value associated with putting one complete unit in place, including materials costs, labor costs, waste, and equipment costs. Again, implementation of this method is very easy and generally sufficient for monitoring basic tasks. The two methods, Units/MH and $/Unit, offer a simplistic approach to productivity measurement and, based on the literature review, are perhaps the most widely used. The unit of measurement may be easily changed, and the methods provide quick data collection for most crafts on the job. When the units encompass a greater amount of work effort, this performance indicator fails to break down the elements of production to a measurable scale. For example, the placing of one masonry unit can be broken down to the number of man-hours per unit or the dollars per unit with little mathematical manipulation. However, in contrast, the placement of one pressure vessel does not readily separate into measurable units quite so nicely. When the magnitude of the job surpasses easily quantifiable components, new performance indicators must be used. At this point, accurate performance reporting requires baseline references or detailed estimates and schedules to properly monitor operations:
- **Cost:** Job Cost reporting may also be used to predict the success or failure of the overall construction effort. Job cost involves monitoring performance by comparing current costs accrued to the budgeted costs in dollars allocated for the work in place completed to date (Alfeld 1988; Thomas and Kramer 1988) This approach does not generally single out particular operations, but provides an overall summary of adherence to the budget.
- **On-Time Completion:** The On-Time Completion method parallels the job cost approach in that it serves as a holistic measurement of performance according to schedule duration, and the two are often incorporated to better understand the current construction performance. On-time milestone completion determines if construction is proceeding according to schedule. Acceptable productivity is measured solely on the basis of time spent with respect to the overall scheduled duration.
- **Resource Management:** Calculating productivity changes by the amount of materials, tools, and equipment expended during the construction operation is another quantitative performance indicator. Resource Management is a valuable tool for monitoring the material waste prior to a change and then comparing that amount to the waste incurred after the initiated change.
- **Quality Control/Rework:** Rework traditionally is responsible for 6–12% of the overall expenditure for a construction project. However, the costs associated with rework are at a premium and they greatly increase the overall cost of the job. Calculating the change in the number of man-hours and material costs for repairing work in place or rehandling materials can be an effective tool for measuring overall project performance. By reducing the amount of rework on a job, the profits associated with the specific task can increase dramatically.
- **Percent Complete:** The Percent Complete method can be estimated by the foreman or supervisor at the work site. This method is useful for relatively minor tasks, usually short in duration, where other more costly and time-consuming methods cannot be justified (Thomas and Kramer 1988). This generally accepted method is widely used in preparing the monthly application for payment request. This approach to the percent complete method of reporting is only as good as the

J. Constr. Eng. Manage., 2003, 129(2): 142-151

person responsible for the evaluation. As a project manager gains more experience, the method gains accuracy. An alternative Percent Complete method would take measured quantities completed divided by the total estimated quantity to determine Percent Complete progress.

- **Earned Man-Hours:** The Earned Man-Hours approach is one of the more popular baseline methods for measuring performance. Man-hours are earned for completed work in place. By multiplying the estimated unit rates by the amount of work completed (units), one arrives at the number of man-hours earned for that particular task to date. Subtracting the actual number of man-hours charged to a task from the number of earned man-hours provides an indicator of job productivity (Alfeld 1988).
- **Lost Time Accounting:** Lost Time Accounting is another important area that can easily be turned into a large return. Like rework, lost time is wasted work hours with no return. This method measures productivity according to the number of man-hours lost due to idle time such as waiting for materials, instructions, or daily work orders. By reducing the average worker idle time, the productivity of the workers will increase. The only expense to the company would be to preplan the construction operation to increase efficiency.
- **Punch List:** The final quantitative performance indicator to be discussed in this study is the Punch List item. There are numerous ways to report punch list items, including the total value of the punch list items versus total contract amount, or the man-hours for punch items as a percentage of the total man-hours for the entire job. The use of punch list reporting occurs at the end of any particular task or project.

Qualitative Performance Indicators

Qualitative performance indicators are not commonly accepted as reliable performance and productivity evaluation tools due to their perceived difficulty and/or inability to be measured. Unlike quantitative performance indicators, qualitative indicators do not appear in the estimating/costing system utilized by the majority of construction films.

According to the 1997 Edition of Webster's Dictionary, the definition of qualitative is: ''relating to, or involving quality or kind.'' Patton (1986) offers a more technical definition in the context of program evaluation: ''Qualitative data consists of detailed descriptions of situations, events, people, interactions, and observed behavior; direct quotations from people about their experiences, attitudes, beliefs, and thoughts; and excerpts or entire passages from documents, correspondence, records, and case histories.'' For the purposes of this research, qualitative indicators are defined as those indicators that have the potential for measuring the behaviors of workers on the job site.

The following qualitative performance indicators are addressed in this research, and each item will be defined individually in the remainder of this section:

- **Safety:** Safety is a major concern for every construction company, regardless of the type of work performed. Safety is measured quantitatively through incidence rates and Experience Modification Ratings (EMRs). The objective of a safety program is to eliminate losses due to poor working practices that could impact workforce well-being (Hislop 1991), and it is therefore classified as a qualitative KPI in this study. Safety may be used for performance reporting by measuring the change in the number of accidents or safety-related problems on the job site. Poor safety can have a detrimental impact on the job. In the case of accidents, work may stop in one area of the job, worker morale may drop, and productivity will decline (Alfeld 1988). Tracking job performance using safety may allow the company to see benefits due to worker training or due to modification of the construction process. These changes may not always result in immediate cost savings.
- **Turnover:** Turnover is a problem that plagues the construction industry and indirectly increases overall costs. Measuring the costs associated with workers leaving the company to seek work elsewhere, and the cost of training new employees to fill those positions, is a valuable tool for determining overall construction performance. High percentages of employee turnover results in lower average worker skills on the site, which can affect the quality of work being performed. Furthermore, funds spent training new employees increase the cost of construction operations. By monitoring the change in company turnover, impacts on performance may be measured (Warren 1989).
- **Absenteeism:** Performance evaluation based on absenteeism offers more concrete units for measurement. Absenteeism can be measured by the change in the number of lost man-hours due to absences over the duration of the construction project. A decrease in the number of lost man-hours directly results in increased production or output on the job. Decreasing the number of absences helps maintain the budgeted manpower needed to complete the work according to schedule (Laufer 1985; Warren 1989; Halligan et al. 1994).
- **Motivation:** The most difficult indicator to measure is worker motivation. For this research, motivation is defined as the worker's attitude towards the job and the environment created on the job site. The definition can be taken one step further to mean the willingness of employees to perform the task at hand to management's satisfaction (Oglesby et al. 1989).

Although qualitative performance indicators may not be categorized under an estimating/cost account, their impact on project costs are very real. Qualitative indicators play an important role in practically every area of the construction process. Managers who do not incorporate these qualitative indicators may fail to recognize one important area that can have an impact on performance evaluation (Warren 1989).

Research Hypotheses

The data obtained from the survey of construction executives and project managers have produced a variety of information on perceived KPIs and their level of usefulness in measuring productivity. The following list contains the hypotheses that were tested:

- H1: There exists a set of common perceived KPIs for all construction companies, regardless of construction industry sector.
- H2: Differences exist among the different levels of management in their set of perceived KPIs.
- H3: Perceived KPIs vary depending on the number of years of experience of the respondent.
- H4: Differences in perceived KPIs will exist across annual company volume.
- H5: Perceived KPIs will differ among reported levels of self-performed work.

The data obtained from the construction industry survey was used to test these hypotheses. The hypotheses were tested using basic statistical analysis and Statview software (Abacus 1994). The analyses included such things as determining the mean, standard deviation, standard error, and number of respondents. The Student's *t*-test (Moore 1995) was used to test for differences among the mean responses for the applicable hypotheses.

J. Constr. Eng. Manage., 2003, 129(2): 142-151

Research Methodology

To determine and analyze the set of perceived Key Performance Indicators (KPIs) utilized by construction executives and project managers in the construction industry throughout the United States, five industry sectors were targeted with the intention of determining whether a difference exists in these KPIs among construction industry divisions. The five construction sectors chosen were: commercial, heavy civil, industrial, mechanical, and electrical. Mechanical and electrical contractors were each assigned a separate sector due to the large percentage of total general construction project costs associated with each one respectively. Similarly, within this framework, differences in the perceived importance of these performance indicators were investigated for both executive and project management levels. Differences in the perceived importance of performance indicators were also determined according to the number of years of construction experience each respondent possessed.

The sample selection of construction companies used in this study was divided into three categories. The first group surveyed was selected from construction executives and project managers employed by the Engineering News Record (ENR) Top 100 Contracting Firms for 1995. This population was approached partially due to their prior involvement in University of Florida research, and due to the overall size of the companies. Their previous involvement with graduate-level research provided a reliable sampling base for this study. A total of 70 surveys were sent to this sampling group.

Desiring a larger sampling, the search was enlarged to include a second group. The second group was chosen from the 1996 Associated Builders and Contractors (ABC) National Membership Directory and Users Guide. Companies were carefully chosen from the directory according to the type of work they performed, and the annual revenue generated. To complement the ENR Top 100 Firms, companies performing between 10 and 40 million dollars annually were selected. Using this approach, data was collected from all five sectors of the construction industry, and a nationwide sample of companies was obtained. Through the division stratification of the sample pool, both large and medium scale construction companies could be included in the final analysis. A total of 30 questionnaires were sent to this sampling group, which, when added to the 70 sent to the ENR Top 100 Contracting Firms, resulted in a total of 100 surveys distributed in phase one of the data collection process.

Following an initial analysis of the survey responses, a third set of 66 surveys were sent to randomly selected contractors with a reported annual volume of at least $50 million, listed in Engineering News Record's Regional Contractor directories for 1995. This sampling targeted the midsize construction companies.

After receiving this third set of responses, a high percentage (39%) of the total number of contractors approached (166) had responded to the survey. Of the contractors that did respond, most were very supportive of the study and put much thought into their answers. The level of response from each of the groups contacted is shown in Table 1. As shown in Table 1, the data collected covers a wide spectrum ranging from the smallest to the largest construction companies.

The industry questionnaires provided responses that could be analyzed according to the basic independent variables of this study. Five (5) hypotheses were tested using the Student's *t*-test for determining statistical differences among means. Using responses from a seven (7) point Likert Scale, the mean value for each item of the survey was determined. To further analyze the initial findings, the Student's *t*-test was used to test for a statistically significant difference in the mean response values among the various industry groups, using a 90% confidence interval (Moore 1995). The Student's *t*-test was selected for its simplicity in identifying whether or not the respondent's opinions were statistically different, thus allowing for the identification of common sets of perceived KPIs, when responses were not found to be significantly different.

Table 1. Survey Questionnaire Response Rate

Industry segment	Sent	Received	Response percentage
ENR Top 100 (Large)	70	15	21
ABC Members, $10-40 Million (Midsize)	30	17	57
ENR Regional Directories (Small)	66	32	48
Total	166	64	39

The major limitation of this study is the small sampling of mechanical and electrical contractors. Given the small number of mechanical and electrical respondents, inferences about the results involving these categories of construction cannot be offered.

Demographics of Respondents

In an attempt to obtain an adequate sampling of the population, a total of 166 construction management personnel were surveyed. A total of 64 surveys (see Appendix) were completed and returned, resulting in a 39% response rate. As shown in Fig. 1, the distribution of the number of responses provides a good overview of the different management levels of the construction industry. Of the 64 total responses used in this study, 39 (61%) were from construction executives and 25 (39%) were from project managers. Based on the belief that self-performance leads to a higher level need for measurement and KPIs, each respondent was asked to give information on their company's level of self-performed work. This information was gathered in order to see if any correlations could be found between self-performance and the resulting KPIs. As shown in Fig. 2, an almost even distribution of responses was collected ranging from ''less than 10%'' to ''more than 76%'' of self-performed work.

With respect to annual volumes, the responses are shown in Fig. 3. The majority (43%) of the respondents work for companies in the ''less than $50 million'' category. This was followed closely by the ''$50–100 million'' category, with 33%. Of the remaining respondents, 5% were from the firms in the ''between $100 and 150 million'' category and 19% were from large firms in the ''over $200 million'' category.

Each respondent, as shown in Fig. 4, was assigned to one of five (5) categories for analysis according to their respective con-

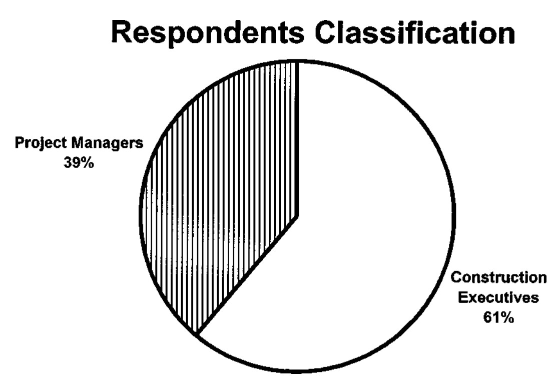

Fig. 1. Survey respondents classification

J. Constr. Eng. Manage., 2003, 129(2): 142-151

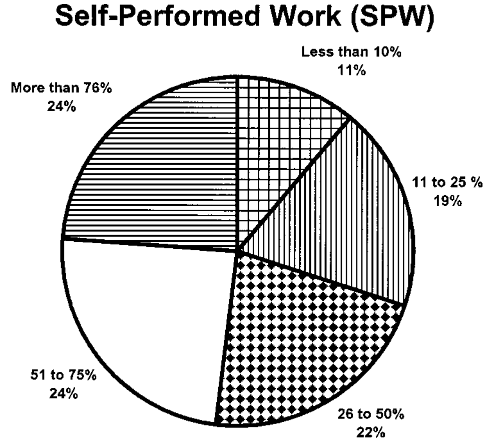

Fig. 2. Survey respondents' level of self-performed work

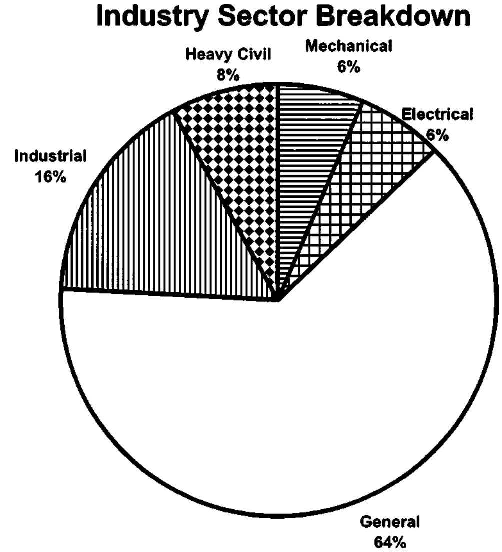

Fig. 4. Survey respondents breakdown by industry sector

struction industry sector. The sectors were: general, heavy civil, industrial, mechanical, and electrical.

While the responses do not equally represent each sector of the industry, the data collected do address all industry sectors and closely mirror the demographics of the construction industry. As shown in Fig. 4, the majority of the respondents classified themselves as general contractors (64%), followed by industrial (16%), heavy civil (8%), electrical (6%), and mechanical contractors (6%).

Analysis of Results

The discussion of the results will provide a review of the original hypotheses, a review of the research objectives, and open observations. Tables and figures are provided to help illustrate the hypotheses being tested.

H1: ''*There exists a set of common perceived KPIs for all construction companies regardless of construction industry sector*.''

To obtain this information, Part 3 of the industry questionnaire required the respondent to rank only the top five KPIs with a score of one (1) being the highest score and five (5) being the fifth highest score. Thus, each respondent was allowed to select only five out of the possible fifteen indicators.

The statistical analysis required a frequency distribution of the fifteen possible responses. The distribution resulted in each indicator receiving a count of the number of scores it received from one to five, and a total number of responses regardless of rank. Many respondents remarked that all five of the indicators selected possessed equal levels of significance. After further review of the data, the exact ranking of the performance indicator proved less important than initially hypothesized. The frequency of each indicator being chosen as one of the top five proved more noteworthy. Those indicators receiving the highest percentage of total responses are shown in Table 2.

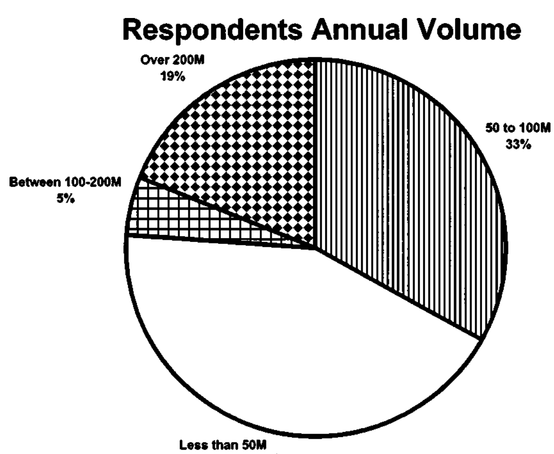

Fig. 3. Survey respondents' annual volume

Further analysis of the data provided a frequency distribution of the indicators according to their total number of top scores. The number of responses marked ''1,'' this being the best obtainable score, were tallied for each indicator. As shown in Table 2, column 2, these KPIs received 73.8% of all possible top rankings (#1). Table 2, column 1, also shows the number of times each KPI was selected in the top five ranking by all the survey respondents. If one were to use only Table 2, column 1, the top ranked perceived KPI would be ''on-time completion,'' since it received 24 top five rankings. However, ''on time completion'' only received 11.8% of the ''#1'' votes. It should be noted that these results are based on total responses and do not reflect specific sectors of construction, different management levels, or experience levels.

The results of both analyses show that six indicators consistently received the highest percentage of respondent confidence. Units/MH, $/Unit, Safety, Cost, On-Time Completion, and Quality Control/Rework received 40% (124 out of 320) of the total number of possible responses regardless of rank. This suggests that these indicators received the greatest perceived significance.

Table 2. Testing for Common Set of Perceived KPIs

KPIs	Number of ''top five'' votes	Percentage of ''#1'' rankings by all respondents
Units/MHR	19	26.5
$/Unit	17	11.8
Safety	23	14.7
Total cost	23	9
On-time completion	24	11.8
Quality control/rework	18	11.8
Total	124 out of 320 (40%)	73.8

J. Constr. Eng. Manage., 2003, 129(2): 142-151

Table 3. Perceived KPI Response by Management Level

Indicator	Executives	Project managers	t-Critical	t-Calculated	Significance
Total cost	6.23	5.96	1.67	0.78	No
QC/Rework	5.46	6.00	1.67	1.693	Yes
On-time	5.46	6.21	1.67	1.863	Yes
Safety	5.84	6.39	1.67	1.42	No
$/Unit	5.42	5.417	1.67	0.013	No
Units/MHR	5.50	5.08	1.67	1.095	No

Note: A seven (7) point Likert scale was used.

The six highest ranked indicators received 78% of the best obtainable scores equal to ''one'' (1) on the 1–5 scale. Regardless of the analysis approach used, the same set of identical indicators resulted, thus supporting the original hypothesis, that ''there exists a set of common KPIs for all construction regardless of division.''

H2: ''*Differences exist among the different levels of management in their set of perceived KPIs*.''

Responses by managers were compiled into two main divisions of management: executives and project managers. The executive group consists of company owners, presidents, vice presidents, chief operating officers, quality managers, and operations managers. Project managers (PMs) comprised those managers who may control individual or multiple construction projects at any given time.

A Student's t-test with a 90% confidence interval was completed using Statview software (Abacus 1994) and a null hypothesis that the difference in the sample means was zero (Mean of Executive = Mean of Project Managers). Table 3 shows the mean value of responses broken down by executives and project managers for all six KPIs along with the Student's t-test values for testing the results. Based on the t-statistic, if the t-calculated is greater than the t-critical, then one must reject the null hypothesis and accept the alternate hypothesis that a significant difference does exist.

The results, as shown in Table 3, also indicate that a statistically significant difference does exist between executive management perceptions and project management perceptions of the on-time completion and quality control/rework KPIs as determined by the t-calculated being greater than the t-critical value.

The significant difference found between project managers and executives for the quality control/rework and on-time KPIs may be due to the different focuses of these groups. While the project manager typically maintains a project level focus, executives tend to have a company-wide focus. This may be further reinforced by the fact that most project management incentive pay is closely related to quality control and schedule.

H3: ''*Perceived KPIs will vary depending on the number of years of experience of the respondent*.''

The mean score was derived for each performance indicator found in the questionnaire according to experience level. All six KPIs were chosen to support the hypothesis and provide a trend of differences in perceived performance indicators according to various experience levels. Table 4 gives the results of this analysis, showing that all KPIs had statistically significant differences among years of construction experience of the respondent.

Table 4. Comparison of Experience Levels and Perceived KPIs for All Respondents' Age Groups

Experience level 1	Experience level 2	KPIs	t-Calculated/t-Critical
5–10 years	15–20 years	Units/MH	−2.06/1.74
5–10 years	25–30 years	Units/MH	−2.07/1.79
5–10 years	10–15 years	$/Unit	2.20/1.81
5–10 years	15–20 years	$/Unit	3.63/1.74
5–10 years	25–30 years	$/Unit	2.55/1.79
15–20 years	20–25 years	$/Unit	2.39/1.71
>35 years	5–10 years	Total cost	2.51/1.79
>35 years	20–25 years	Total cost	1.87/1.72
>35 years	25–30 years	Total cost	2.40/1.78
5–10 years	15–20 years	Safety	1.744/1.74
<5 years	25–30 years	Safety	2.33/1.89
>35 years	5–10 years	QC/Rework	−1.91/1.79
<5 years	20–25 years	QC/Rework	2.18/1.75
5–10 years	20–25 years	QC/Rework	2.14/1.73
5–10 years	25–30 years	QC/Rework	1.98/1.79
<5 years	25–30 years	On-time completion	3.96/1.89

The results support the conclusion that differences do exist in the perceptions of KPIs based upon the number of years of experience of the respondent. Each of the perceived KPIs varied according to experience level; respondents with fewer years of experience tend to be placed in field level positions where completion deadlines are crucial. As managers acquire more experience, they migrate away from the field and into the home office, where a more corporate level approach is taken in considering the KPIs for a particular project.

For instance, the total cost indicator was found to have significant differences between those with more than 35 years of experience and all other categories, except for those who reported less than 5 years experience. Perhaps this is evidence of the initially cost-conscious manager, who as he/she gains more experience, becomes aware of more performance issues other than just cost, only to become an executive whose apparent concern is for the company's bottom line.

Considering the on-time completion KPI, the significant difference between managers with less than 5 years and managers with 25–30 years experience may be due to the newer, less experienced managers being exposed to tight field schedules, while the more experienced managers have seen that projects almost always get done near the contract completion date.

H4: ''*Differences in perceived KPIs will exist across annual company volume*.''

The mean and variances of the four (4) KPIs by company, which were found to have statistically significant differences, are shown in Table 5, listed by level of annual company income. Statistically significant differences were found among four of the

Table 5. Selected Mean KPI Responses by Company Volume

Volume	n	Safety		On-Time		$/Unit		Total Cost	
		Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
<$50M	17	5.89	2.01	5.88	0.74	5.12	1.24	6.11	0.81
$50–100M	14	6.71	0.22	6.14	1.06	5.62	1.26	6.57	0.73
$100–200M	2	7.00	0.00	3.50	4.50	7.00	0.00	7.00	0.00
>$200M	8	5.75	1.64	5.38	1.98	5.13	2.13	5.38	1.99

J. Constr. Eng. Manage., 2003, 129(2): 142-151

Table 6. Safety and Total Cost KPI Differences by Company Volume

Volume 1	Volume 2	KPI	t-Calculated	t-Critical
\$50–100M	<\$50M	Safety	2.841	1.699
\$50–100M	>\$200M	Safety	2.568	1.725
\$50–100M	>\$200M	Total Cost	2.501	1.725

six KPIs with respect to company volume. However, due to the low response rate in the \$100–200M category, the differences found in \$/Unit and On-Time Completion with other volume categories were discarded.

As shown in Table 6, the KPIs showing a significant difference were safety and total cost. With respect to safety, the significant difference may be better explained due to the high difference in variance between the volume categories (2.01 versus 0.22 and 0.22 versus 1.64) as shown in Table 5. In terms of total cost, the mean response for the \$50–100M group was 6.57/7.00, while the >\$200M respondents' mean was 5.38/7.00. Similar to the safety result, the \$50-100M subgroup had a lower variance (0.73 versus 1.99). These lower variances may indicate a more common perception of these KPIs among the respondents in these volume categories.

H5: "*Perceived KPIs will differ among reported levels of self-performed work*."

This hypothesis is based on the top KPI selected by the respondents and their respective levels of self-performed work. Table 7 shows the differences in KPIs among various levels of self-performed work found in the study.

The more self-performed work a company does, the greater the interest in the quality control/rework KPI. This result is likely due to fact that the cost associated with rework is directly related to overall profitability. When looking at the lower levels of self-performance (<10%), the contractor is functioning more like a construction manager. Accordingly, the contractor has a greater need to control and coordinate subcontractors in the timely completion of their work as indicated.

Conclusions

A common set of KPIs was defined, and it was determined that a statistically significant difference existed between the general, heavy civil, and industrial construction sectors. Due to the limited sample size, no conclusions could be reached about the mechanical and electrical construction sectors. Further analyses indicated differences in KPIs according to the level of management and the number of years of experience. The research contained in this paper should be used to spark further interest in establishing trends in KPIs for the construction industry.

This study has provided further data on Key Performance Indicators (KPIs) at the project level of the construction industry and has brought up questions that require further research. It must be understood that the industry is not a stagnant environment; therefore, constant monitoring to improve the reporting methods must be sought. Those wishing to utilize the information provided in this study in determining construction performance should use the Key Performance Indicators (KPIs) in conjunction with those indicators that monitor the internal objectives of their own company.

Table 7. Perceived KPIs by Level of Self-Performance

Level self-performed (%)	Response (%) (mean out of 7.00)	Top rated KPI
Up to 10	75 (5.50)	On-time completion
11–25	No preference	No preference
26–50	57 (5.63)	Units/MH
51–75	38 (5.22)	Safety
More than 75	33 (5.78)	Quality control/Rework

The six (6) indicators consistently perceived as being highly significant to the survey respondents include: Quality Control, On-Time Completion, Cost, Safety, \$/Unit, and Units/MHR. This suggests that the six indicators may be used as the foundation for reporting performance, with additional indicators supplementing the monitoring system depending on construction sector, management level, and experience.

Due to the different focuses of project managers and executives, a significant difference was found between the quality control/rework and on-time KPIs for these two groups. While the project manager typically maintains a project level focus, executives tend to have a company-wide focus. In addition, most incentive pay for project managers is closely related to quality control and schedules.

The total cost indicator was found to have significant differences between those with more than 35 years of experience and all other categories except for those who reported less than 5 years experience. Perhaps this is evidence of the initially cost-conscious manager, who as he/she gains more experience, becomes aware of more performance issues other than just cost, only to become an executive whose apparent concern is for the company's bottom line.

Further analysis of the on-time completion KPI indicated that there existed a significant difference between managers with less than 5 years experience and managers with 25–30 years experience. This difference maybe be due to the newer, less experienced managers being exposed to tight field schedules, while the more experienced managers have seen that projects almost always get done near the contract completion date

It was also determined that the higher the level of self-performed work by a construction company, the greater the importance of the quality control/rework KPI. This result is likely due to fact that the cost associated with rework is directly related to overall profitability. When looking at the lower levels of self-performance (<10%), the contractor is functioning more like a construction manager and their established KPI is on-time completion. Accordingly, the contractor has a greater need to control and coordinate subcontractors in the timely completion of their work as indicated. Following that trend, contractors self-performing 26–50% of their work volume selected Units/MHR as their KPI. Those self-performing 37–75% focused on Safety as their KPI, since, understandably, more self-performance means more workers being exposed to safety risks. Contractors with the highest levels of self-performed work indicated that Quality Control/Rework was the most important KPI because, when self-performing 75–100% of the scope of work, quality control directly affects profitability.

Construction professionals need to better monitor and control their organization's performance at both the field and office levels. The KPIs identified by this study offer a sound approach towards completing successful project-level performance monitoring and evaluation. In conclusion, it is recommended that more in-depth studies should be performed to better understand KPIs.

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J. Constr. Eng. Manage., 2003, 129(2): 142-151

Appendix: Construction Industry Survey

This survey is being conducted by the University of Florida's M.E. Rinker, Sr. School of Building Construction in conjunction with the National Center for Construction Education and Research. All information provided will be strictly confidential. If you have any questions regarding this survey instrument, please contact Dr. Robert F. Cox or Dr. Raymond Issa @ 352-392-5965. Thank you in advance for your contribution to this study.

Company:______________________________Tel: ______________ FAX:______________
Type of Construction: ______________________ Annual Volume: ____________________
Respondent's Name: ______________________Title: ____________Total Years of Experience: __________
Please provide a break down of your years of experience at the following positions in Construction:
Craft Level________ Field level Manager ________ Project Manager __________ Executive ______________

PART 1: LABOR WORK FORCE DEMOGRAPHIC INFORMATION

Average Level of Work force Education: (Please circle the education level which best describes each classification below and provide average pay / age.)

							Avg. Pay/ Avg. Age:
Craft Level	HS Diploma	Some Community College	AA/AS	Some College	BS/BA	MS/MA	_____/___
Field Managers	HS Diploma	Some Community College	AA/AS	Some College	BS/BA	MS/MA	_____/___
Project Managers	HS Diploma	Some Community College	AA/AS	Some College	BS/BA	MS/MA	_____/___
Executives	HS Diploma	Some Community College	AA/AS	Some College	BS/BA	MS/MA	_____/___

What percentage of your work is self-performed? 0% 1-10% 11-25% 26-50% 51-75% 76-100%

Does your company use performance evaluation for incentive programs such as pay raises, project bonuses, etc.? YES___ NO___
Does your organization promote Cross Training? YES ______ NO ________
Does cross training increase the worker's wages? YES ______ NO ________

Which of the following is the focal point for training in your organization? (Please only check one!)
________Profits______ Safety______ Productivity ______ Motivation / Morale ______ Quality _________Competitiveness

PART 2: Please rate the following measures with respect to their relevance in measuring field level performance.

		LOW						HIGH	
1.	**Units/MH:** Units per man-hour is the measure of the number of completed units put in place per individual man hour of work.	1	2	3	4	5	6	7	N/A
2.	**$/Unit:** The dollar value associated with putting one complete unit in place.	1	2	3	4	5	6	7	N/A
3.	**Safety:** Measure the change in the number of accidents or safety related problems on the job site.	1	2	3	4	5	6	7	N/A
4.	**Turnover:** Measuring the costs associated with workers leaving the company to seek work elsewhere. Ex. cost of training new employees.	1	2	3	4	5	6	7	N/A
5.	**Resource Measurement:** Calculating productivity changes by the amounts of materials, tools, and equipment expended during construction operations.	1	2	3	4	5	6	7	N/A
6.	**Cost:** Monitoring productivity by comparing current costs to budgeted costs in dollars.	1	2	3	4	5	6	7	N/A
7.	**On-Time Completion:** Construction according to schedule indicates acceptable productivity.	1	2	3	4	5	6	7	N/A

J. Constr. Eng. Manage., 2003, 129(2): 142-151

8.	**Absenteeism:** The change in the number of lost man hours due to absences.	1	2	3	4	5	6	7	N/A
9.	**Quality Control / Rework :** Measure how closely the job conforms to plans, specs, code requirements, and accepted industry standards for workmanship.	1	2	3	4	5	6	7	N/A
10.	**Earned Value Reporting** (Incremental Milestone Method): Use completion of specific milestones to measure productivity.	1	2	3	4	5	6	7	N/A
11.	**Percent (%)Complete**: A subjective evaluation is made by the foreman or supervisor.	1	2	3	4	5	6	7	N/A
12.	**Earned Man-hours**: Man-hours are earned for completed work in place. Multiplying the estimated unit rates by the amount of work completed(units) gives the number of man-hours earned for that particular task to date. Subtracting the actual number of man-hours charged to a task from the number of earned man-hours indicates degree of job productivity.	1	2	3	4	5	6	7	N/A
13.	**Lost Time Accounting:** Measures productivity using to the number of man-hours lost due to idle time. i.e. waiting for materials, instructions, etc.	1	2	3	4	5	6	7	N/A
14.	**Motivation:** Workers' attitude towards the job and the environment created on the job site. (i.e., # of Grievances)	1	2	3	4	5	6	7	N/A
15.	**Punch List:** Value of item versus project allocation. ex. Man-hours for punch item/total man-hours for job.	1	2	3	4	5	6	7	N/A

PART 3

Please rank the top 5 key performance indicators according to how useful they are in monitoring performance of field operations in your company.

1 = Most useful

5 = Fifth most useful

_____ Units/MH
_____ $/Unit
_____ Safety
_____ Turnover
_____ Resource Management
_____ Cost
_____ On-Time Completion
_____ Absenteeism
_____ Quality Control / Rework
_____ Earned Value Reporting (Incremental Milestone Method)
_____ Percent (%) Complete
_____ Earned Man-hours
_____ Lost Time Accounting
_____ Motivation
_____ Punch List

PART 4

Please write any comments in the space provided below concerning key performance indicators. If you feel we have failed to address any key performance indicators or tools for measuring productivity let us know. Any feedback will be greatly appreciated.

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