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ASSESSING THE MANAGEMENT PRACTICES FOR SMALL TO MEDIUM SIZED CANADIAN GENERAL CONTRACTOR ORGANIZATIONS

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Abstract: This paper describes a research study entitled Enhancing the Performance and Productivity of the Canadian Construction Industry through Appropriate Digital Technology Adoption. The study was completed by researchers from four regions across Canada over the period of August 2013 to March 2014. The underlying purpose of the study was to assist in the development of decision-making tools to support the construction industry in the successful adoption and implementation of new technologies. The study was accomplished by completion of the following steps: (1) an existing framework for the assessment of management practices at the project level for general contractors in the construction industry was refined and extended; (2) a standard assessment tool was developed and administered to 25 small to medium sized commercial/institutional building general contractor organizations, resulting in the identification of potential opportunities for improvement; (3) opportunities for improvement were validated with organizations; and (4) the assessment results were aggregated to provide an initial benchmark of the level of implementation of management practices. The assessment included 117 practices, across nine practice areas, and grouped as planning and control. The aggregated assessment results are indicating that at an industry level, the management practices in need of improvement that relate more directly to digital technologies are becoming clearer and include: Time - better utilization of the capabilities of existing scheduling software; Cost - improve the integration between time management and cost management software; Scope - improve the capture of as-built information and the management of warranty and operation and maintenance information; Quality - capture and categorize rework and non-conforming work; Materials - implement materials tracking and on-site management; and Information and Communication - implement processes to assess the performance of information and communication processes and use structured forms for information capture. The study built on previous work and extended it with respect to gaining insight on practices from the perspectives of the level of implementation and the consistency with which a practice is employed. To further extend this work, partnerships are being developed with national industry organizations to broaden the application of the assessment framework, thereby expanding the benchmarking dataset.

1 INTRODUCTION

Impediments to increasing the rate of innovation and improving productivity in the Canadian Construction Industry are related to accessing knowledge in the appropriate form to support decision making, and realizing the necessary capacity to successfully adopt and implement new technologies (or methodologies). This research project continues efforts to provide solutions to overcoming these barriers in support of digital technologies adoption. The project was undertaken with the support of the Digital Technologies Adoption Pilot Program administered by National Research Council Canada's Industrial Research Assistance Program (NRC IRAP). This paper also represents an abbreviated version of the final results of this project (UNB CEM 2014).

The project builds on a method for a comprehensive assessment of construction companies' operational processes and identifies areas with the potential to improve performance and productivity through successful adoption. The enhanced methodology is applied in a series of diagnostic projects with construction companies in four geographical regions (the Canadian Provinces of British Columbia, Manitoba, Ontario, and Nova Scotia) with the intention of: 1) identifying candidates for technology adoption projects, and 2) adding to an existing benchmarking dataset of management practices for the construction industry.

The project was accomplished by completion of the following objectives:

1. Critique and further refinement of an existing framework for conducting a diagnostic assessment of digital technologies in the construction industry at an organization level.
2. Identify regions for application and willing companies that will form a representative group in the construction industry.
3. Assess each individual representative company to determine both current capabilities and opportunities for improvement (identifying practices and processes that are lacking, and those that could be enhanced through digital technology adoption).
4. Aggregate the analysis of the individual assessment to an industry level to identify current capabilities and trends in management practices.

The intended audience for this paper is practitioners that are considering a benchmarking of their construction management practices and, more broadly, those attempting efforts in establishing benchmarking programs within the construction industry.

1.1 Refinements to Framework for Diagnostics Assessment

The first step in the research project was to complete a critique and refine the existing framework from a previous study (UNB CEM 2013) for conducting a diagnostic assessment of digital technologies in the construction industry at an organization level. The existing framework was developed based on the foundation provided by previous work in the assessment of organizational management practices within the construction industry. In summary, the following efforts were used to support the development of the framework:

1. The Canadian Construction Sector Council's National Performance and Productivity Benchmarking Program (Fayek et al. 2010; Fayek et al. 2008; Nasir et al. 2012).
2. The Nova Scotia Construction Sector Council's Functional Information Technology Project (Rankin 2010).
3. The researchers' previous research in assessing management practice maturity (Goggin et al. 2010, Willis and Rankin 2012).
4. Standard references for organizational maturity (PMI 2005).

The result was the adoption of nine management practice areas. Each area of management practices is a synthesis of numerous sources of commonly employed best practices within the construction industry. The following notes describe the scope and context of the practices:

1. Practices are intended within the scope of a design-bid-build type project versus any form of design-build-operation project (e.g., less emphasis on financial management).
2. Practices being examined are common to general contractors in commercial, institutional and infrastructure projects (e.g., equipment management is excluded as it is considered heavy-civil specific).
3. Although some practices are normally performed in a home-office scenario (i.e., planning practices), the emphasis is project (site)-level practices.

With this as a starting point, a broader search on assessment methodologies in the context of digital technologies and organizational management practices was completed at each research location. Materials reviewed included existing international standards for organizational project management practices and techniques for their application to an assessment framework:

1. PMI's Construction Extension to the Project Management Body of Knowledge (PMI 2003).
2. UK's PRINCE2, PRojects IN Controlled Environments, Version 2 (OGC 2002).
3. ISO's Standard 21500, Guidance on Project Management (ISO 2011).
4. IPMA's Competence Baseline, Version 3 (2006).

The results were used as the basis of identifying opportunities to improve the existing framework. The following summarizes the areas for improvement and actions undertaken to complete the refinement.

1. The scope of management areas, and project practices.
 - The existing framework is based on practices derived from PMI PMBOK and its management processes where some areas (e.g., integrated, risk, procurement) have been incorporated into others (e.g., cost, scope). This is a reasonable structure to continue with and can be cross-referenced with other standards if required for comparisons.
 - It is anticipated that the structure will work in the future as additional practices emerge.
 - There is consensus that the area of information practices needs to be improved.
 - There is consensus that direct assessment of project performance should remain outside the scope of the framework.
2. The capture of the level of maturity of a practice and the influence of the complexity of a project.
 - Modifications were made in order to gain more insight in the level of implementation of practices with respect to the concept of the "maturity of practice" (e.g., how formal it is) and the influence of the complexity of an application (e.g., size of project). A project complexity metric is proposed for use with each company to establish a type of best-typical-worst scale and then collect these for each practice.
 - Using multiple participants in the same company for the assessment will provide more insight on opportunities and increase the validity of the results.
 - If there are instances where it makes sense from a company perspective to collect data from multiple participants, consideration will be given to collect these separately and then reconcile these multiple responses in a group setting.
3. Capturing the motivation behind the use or non-use of a practice.

- A categorization of practices based on their source of motivation (e.g., voluntary, owner driven, legislated) was considered as an addition to the survey questionnaire.

1.2 Project Complexity

Project management practices vary with the complexity of an organization's projects. Project complexity is measured by comparing it to other projects within the same industry sector. This study adopts the project complexity definitions used by the Construction Industry Institute (CII)'s Benchmarking and Metrics Program (CII 2008), which measures project complexity on a scale of 1 to 7 (low to high) by asking companies to rate their projects' complexity compared to other typical projects within the same industry sector (e.g. commercial, institutional, infrastructure, etc.). The level of complexity for typical projects undertaken by a company is assessed with the following definitions:

1. Low complexity: projects are categorized by the use of well-established, proven technology, a relatively small number of process steps, a relatively small facility size or process capacity, a facility configuration or geometry that your company has used before, and well-established, proven construction methods.
2. Average complexity: projects are categorized by the use of established technology, a moderate number of process steps, a moderate facility size or process capacity, a facility configuration or geometry that your company has used before, and established, proven construction methods.
3. High complexity: projects are categorized by the use of new, "unproven" technology, an unusually large number of process steps, large facility size or process capacity, new facility configuration or geometry, and new construction methods.

2 PRACTICES

Table 1 is a summary of the nine practice areas and the grouping of practices under the basic management categories of planning and controlling. Each grouping contains multiple practices.

Table 1: Practices by management area with groupings.

Management Area	Practices Grouping	
	Planning	Controlling
1. Time	Schedule development; Resource management; Schedule analysis	Schedule control
2. Cost	Cost estimating; Estimate analysis	Cost control
3. Quality	Quality planning; Quality assurance	Quality control; Quality assurance
4. Scope	Scope planning; Risk management	Scope control; Contract closeout
5. Safety	Health and safety planning; Safety equipment; Hazard management	Safety equipment; Hazard management
6. Human Resources	Human resource planning	Human resource analysis
7. Materials	Materials planning; Materials coordination	Materials control; Materials coordination; Materials inspection and maintenance
8. Information and Communication	Information and communication planning	Information and communication analysis; Information and communication control
9. Environmental and Waste	Environmental and waste planning; Environmental and waste analysis	Environmental and waste control

2.1 Protocols for Data Collection

Within the management areas, each practice is assessed for two factors:

1. The level of implementation (how often is the process used?) for a typical project performed by your organization, on scale of: never; rarely; sometimes; often; or always.
2. The level of consistency (how formally is the process defined and managed?) for a typical project performed by your organization in which the practice is applied, on the scale of: ad-hoc (the process is determined as needed); repeatable (the process is carried out consistently from one occurrence to the next); defined (the process is formally defined and documented); standard (the process is formally standardized throughout the company); or improving (the process undergoes formal review and ongoing improvement).

Additionally, open-ended questions invite information about additional management practices within each area, and situations where there are significant exceptions to the implementation or consistency of a typical practice.

The practices were then converted to a survey format to serve as a script for face-to-face interviews for data collection. Table 2 summarizes the format of the survey and provides examples of the questions.

Table 2: Overview of survey questions for initial data collection.

*For the following statements of management practices, please indicate the level of **implementation** (how often is the process used?) and the level of **consistency** (how formally is the process defined and managed?) for a **typical** project performed by your organization.*

Schedule development

1. A standard work breakdown structure (e.g., CSI MasterFormat) is used to define the activities/tasks for project schedules.

<i>implementation</i>	<input type="checkbox"/> never	<input type="checkbox"/> rarely	<input type="checkbox"/> sometimes	<input type="checkbox"/> often	<input type="checkbox"/> always
<i>consistency</i>	<input type="checkbox"/> ad-hoc	<input type="checkbox"/> repeatable	<input type="checkbox"/> defined	<input type="checkbox"/> standard	<input type="checkbox"/> improving

The data collection protocols (i.e., basis of the study, method of data collection, and survey questions) were reviewed and approved by the UNB Research Ethics Board, per the Canadian Tri-Council (CIHR, NSERC, SSHRC) policies for research involving humans.

3 INITIAL ASSESSMENT

At each geographical location an initial list of general contractors was identified as potential participants for assessment. In most cases, the cooperation of local construction associations was solicited to assist in developing these lists. Upon first contact with each organization the general intent of the project was explained and survey/interview respondents identified. This was sometimes followed by a face-to-face meeting to further describe the study but in most cases the next step was administering the scripted interview for initial data collection on practices. All participants in the interview were senior managers in the organization with direct experience in the execution of all management practices at the project level. Each scripted interview session lasted between three to four hours and was conducted by the same researcher (either face-to-face or by phone) in each geographical location for consistency. To protect the confidentiality of participating organizations, none are directly or indirectly identified. A total of 25 companies were assessed.

3.1 Overall Assessment

Subsequent to the completion of the initial data collection a summary analysis was provided to each participant in the form of a “box and whisker” diagram. The results provided are an aggregation of scores

based on the initial assessment of all organizations. The results in Figure 1 are summarized by management areas to give a general overview of the average level of implementation. Each practice is weighted equally with a maximum score of 5 corresponding with the highest level of implementation and a score of 1 corresponding to the lowest level of implementation. The maximum and minimum scores correspond to practices within each area and the boxes indicate the variance across companies within each management area. Figure 2 provides additional insight with a breakdown of the management step within each area.

In general, the traditional management areas of *time*, *cost*, and *scope*, are performed at a higher level. As expected, *safety* is at the highest level of implementation. Next are *quality*, *human resources*, and *information and communication*. The lower levels of implementation are practices in *materials*, and *environmental and waste*. As depicted in Figure 3, *planning* practices are implemented at a higher level. However, this is not the case for both *scope* and *quality* (with higher scores of implementation for *control* practices).

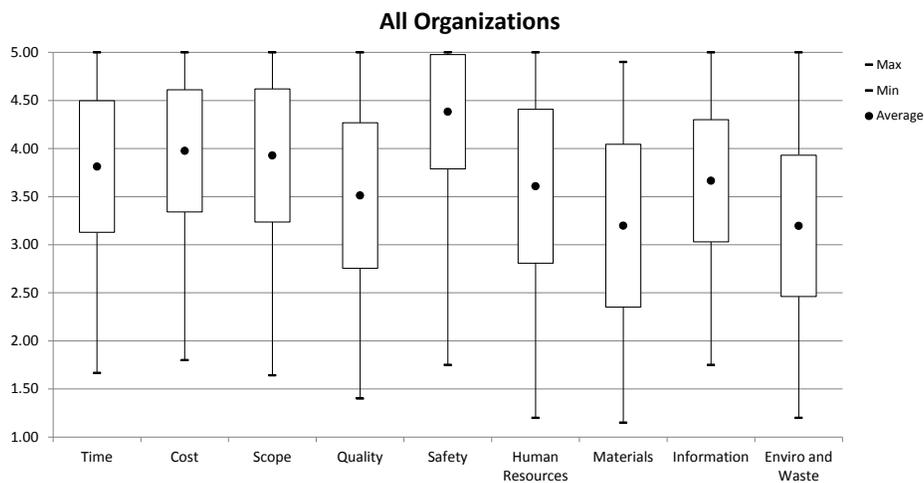


Figure 1: Aggregated implementation score for practices by nine management areas.

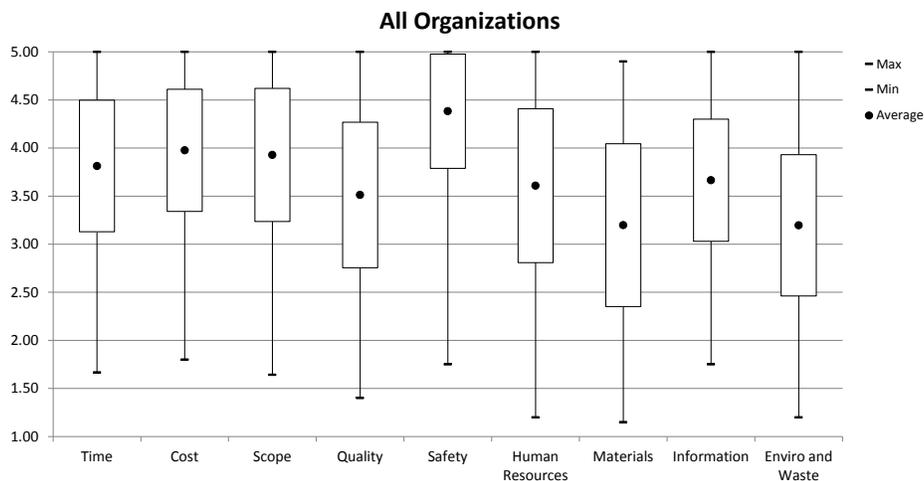


Figure 2: Aggregated implementation for all practices by management area and step.

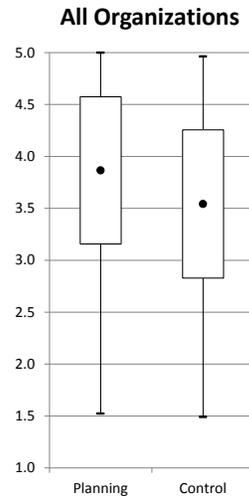


Figure 3: Aggregated implementation score for all practices by management step.

3.2 Individual First Stage Analysis

At the same time the overall summary of practices was provided, each company also received an overview of their scores at the management area level and a more detailed description of where opportunities for improvement were identified. This was captured in a single page, which contained a radar chart (Figure 4) that measured the company against the average of all companies and a summary of opportunities for improvement. These results were used to further engage each company on their practices and to validate the opportunities for improvement.

The opportunities for improvement were aggregated under each management area with the frequency of common opportunities also indicated. The most frequently identified opportunities in each management area are summarized as follows:

1. *Time*: incorporate uncertainty in project schedules during planning; use short-term look ahead scheduling during project execution; communicate the project schedule to all project participants; better utilize the capabilities of existing scheduling software.
2. *Cost*: improve the integration between time management and cost management software; improve internal reviews of estimates; improve the use of expertise in the development of estimates.
3. *Scope*: improve project risk identification and management; improve the capture of as-built information and the management of warranty and operation and maintenance information.
4. *Quality*: capture and categorize rework and non-conforming work; perform internal analyses of common work processes for improvement.
5. *Safety*: improve the hazard planning and inspection planning processes; improve the management of safety equipment, materials and resources management.
6. *Human Resources*: implement team building practices on projects; implement performance assessment on a project basis.
7. *Materials*: implement materials tracking and on-site management; integrate procurement of materials with project scheduling.
8. *Information and communication*: implement processes to assess the performance of information and communication processes; use structured forms for information capture.

9. *Environmental and waste*: overall the practices in this area are the least mature; therefore in general, consideration should be given to the overall management approach.

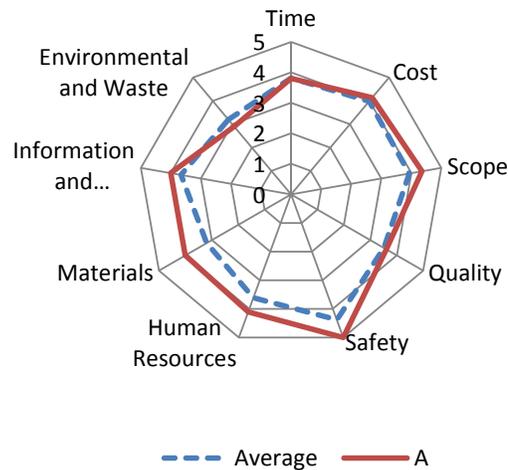


Figure 4: Example of radar chart of initial assessment.

3.3 Validation and Final Analysis

Validation of the results and opportunities for improvement identified was completed by either a face-to-face meeting or phone call, at which the overall results were reviewed and additional insights provided, followed by a discussion of each individual opportunity. Each validation meeting was completed in a single session of one to two hours.

In general, for each company, the initial opportunities were classified into three groups:

- identified as an opportunity and ready to pursue
- identified as an opportunity but not ready to pursue
- at this point not able to rationalize the investment to improve in the area identified
- currently satisfied with practices in the management area identified

Of the 25 organizations that completed the initial assessment, twelve were available to further validate the results and opportunities for improvement identified.

4 AGGREGATION AS A BENCHMARK

As noted, Figures 1 and 2 summarize the average score for an aggregation of practices in each management area. This was used for the purpose of validating opportunities for improvement. These commonly used descriptive statistics in benchmarking can provide additional insight with respect to the practices assessed. It should be noted that at this point the results are not considered statistically significant due to the current sample size.

Figure 3 provides the aggregated practices per a management step classification of practices (i.e., *planning* and *controlling*). At this aggregated level, the assessment indicates that overall there are higher scores for the level of implementation for *planning* practices and conversely overall more variance in the scores for level of implementation of *controlling* practices.

The assessment of management practices reported at an aggregate level for each management area is provided in Figure 4. Apart from the observations noted earlier on the average values for each management area, general observations on the variance of the resulting scores is offered. Management areas with lower variance in the scoring of their level of implementation include *scope* and *safety*, groupings of management areas with higher variance include *quality*, *human resources*, and *materials*. Although not depicted in this paper, general observations for planning practices are that there are higher variances in the scoring of level of implementation for *quality* and *materials*. Whereas for the controlling practices, there are a number of management areas with higher variance in the scoring of level of implementation including: *cost*, *quality*, *materials*, and *human resources*. As part of the final analysis, each individual organization was also provided with a more detailed comparison of their practices against the aggregated group. Figure 5 depicts an example of this comparison.

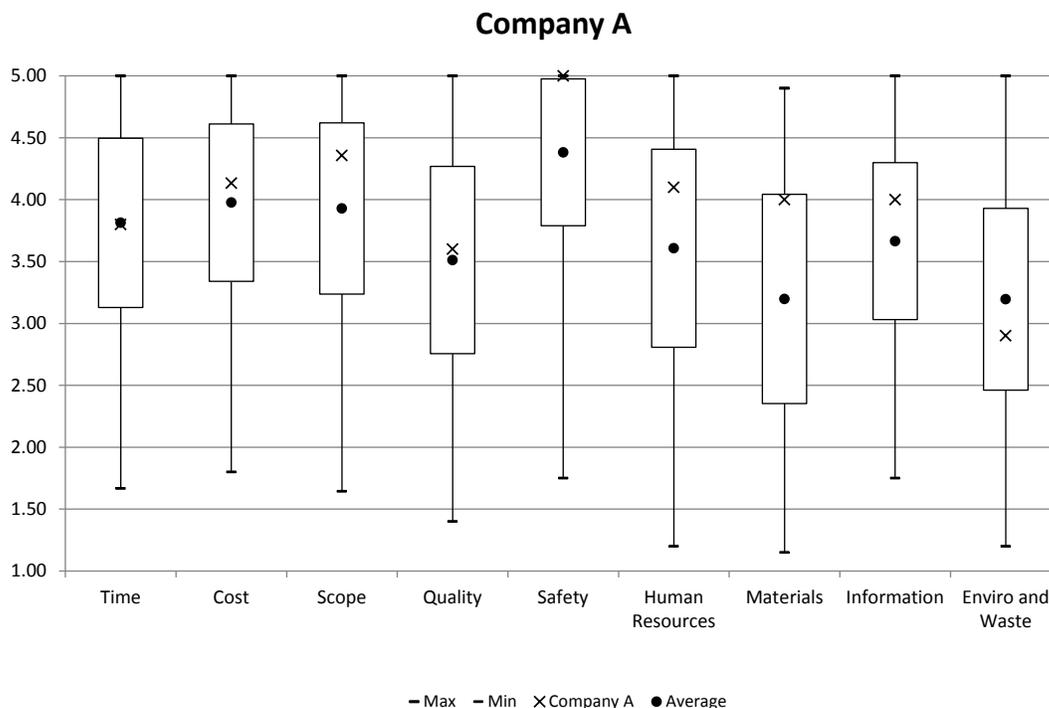


Figure 5: Descriptive statistics example indicating an individual organization.

5 CONCLUSIONS AND FURTHER STEPS

The project resulted in knowledge in a form that is usable to the potential adopter (industry practitioners) for decision making purposes. When aggregated with a previous project, we now have assessment results from 33 (8 from the previous study and 25 from this most recent one) small-to-medium sized general contractors in five geographical regions. The results demonstrate evidence of the common issues that need to be addressed at an industry level.

Also to note is the challenge presented in developing a mechanism of assessment with a common structure while also providing enough depth to be useful for each organization. One of the more positive aspects of the research project was the reaction of members of the construction industry to the research project. Although there were some challenges due to timing, all participants were quite willing to participate and saw the value in having an independent review of their practices, as well as an opportunity to consider exploiting technological solutions to address their needs.

5.1 Next Steps

The refined assessment framework and subsequent data collected and aggregated, serve as an initial benchmarking mechanism for industry management practices at the project level. Results are now available to move forward with a broader dissemination of the framework and its potential to assist in the identification of opportunities for organizational improvements. It is the researchers' intent is to further the application of the framework by adding additional participants on a regional basis, as well as exploring its application in other regions.

Dissemination of the current results is being pursued through partnerships with local and regional construction associations in the form of industry briefs and presentations. In addition, further application of the framework is being explored through partnerships with national level construction industry organizations (e.g., BuildForce).

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