ASSESSING SAFETY MANAGEMENT PRACTICES AND THEIR IMPACT ON PERFORMANCE IN THE CANADIAN CONSTRUCTION INDUSTRY THROUGH ORGANIZATIONAL MATURITY

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ABSTRACT

The construction industry requires an ability to assess a given construction organization's safety performance, and to identify areas in need of improvement. To fulfill this need, a framework has been developed to evaluate a safety management program with an emphasis on organizational processes. The result is an organizational safety maturity model based on the hypothesis that continuous improvement of the safety program denotes higher organizational maturity and greater safety performance. This paper presents the researchers' development of the framework and its current application in collaboration with practitioners. The framework was developed through a literature review of safety performance, safety culture, safety climate, and maturity modeling research. The model consists of six main program components: (1) management commitment, (2) safety policy and standards, (3) worker involvement and commitment, (4) hazard identification, reporting, and control, (5) equipment, materials, and resources, and (6) working environment. These program components are expanded upon according to plan-do-check-act management steps. The framework subsequently defines the varying maturity for each step in each component. Ongoing validation of the framework includes elicitation from occupational health and safety experts, and application to a representative set (in size and expected maturity) of construction organizations. The validation and data collection processes are being completed in collaboration with the New Brunswick Construction Safety Association and WorkSafeNB (a regional government occupational health and safety organization). The framework demonstrates how the assessment can be used to assist improvements in safety management practices.

Keywords: Safety management practices, Organizational management maturity, Safety performance

INTRODUCTION

The construction industry cannot rely on the more common metrics for measuring safety performance as benchmarks through which to pursue improvements. The underlying hypothesis of the research described in this paper is that there is a direct relationship between the maturity of safety management practices and safety performance. It has been established that the safety performance of construction organizations is indicative of many other related aspects of the company, such as employee morale, project costs, and productivity (Mohamed 1999). Therefore, assessing construction safety management practices (at the organizational and industry level) against practices which result in better performance can provide some assistance in determining areas for improvement. This is a complement to measuring performance based solely on lagging metrics for safety performance such as the number of incidents per hours worked. From this perspective, an assessment of safety management practices provides a leading indication of safety performance and indicates, with more precision, areas which should be addressed to positively impact both safety and overall performance.

This paper describes research work that is in progress and is being developed in cooperation with the New Brunswick Construction Safety Association (NBCSA) and WorkSafeNB (a regional government occupational health and safety commission). The ultimate goal of the research is to develop a proactive solution to monitor the safety practices of a given construction company at the organizational level and identify areas that are in need of improvement. This paper will cover the first cycle of developing a framework for safety management and demonstrate how it is being

implemented. The framework is essentially a collection of factors that reflect safety management practices. The factors are assessed through a combination of a series of questionnaires and data validation steps. Validation of the model through consultation with the collaborators and the pilot phase of data collection is in progress.

The framework is being developed for consistency within a national construction industry performance benchmarking effort. It builds on recent safety management research that focuses on the assessment of safety climate and safety culture, and employs the concepts of management maturity modeling. This is accomplished by delineating the key factors into six categories where each category of factors is analyzed according to a plan-do-check-act management cycle. The paper is intended for both industry researchers and practitioners.

POINTS OF DEPARTURE

To place this research in the context of assessing the performance of the construction industry, Figure 1 is presented depicting a high level process view of construction (Fayek et al. 2008). Measuring the performance of the process at some level of granularity (e.g., activity, project, organizational, sector, industry) typically measures the ratio of outputs to inputs (A to A) and the extent to which objectives are achieved (C), under a given set of conditions (B), while employing a set of practices (D). The research described in this paper explores the relationship between safety performance (C) and safety practices (D) and it does so at the organizational level of granularity. The aggregation (e.g., to a sector level) and/or specialization (e.g., to an activity level) of the assessment is not covered in the scope of the framework developed. With generally accepted performance metrics for safety, such as the number of reportable incidents, number of accidents, time lost due to accidents, property loss, etc., firmly established, and for the most part supported by legislation, emphasis is placed on development of the practices and framework for assessing them. This is accomplished through a review and synthesis of more recent construction safety management literature, as well as the adoption of a concept of management maturity.

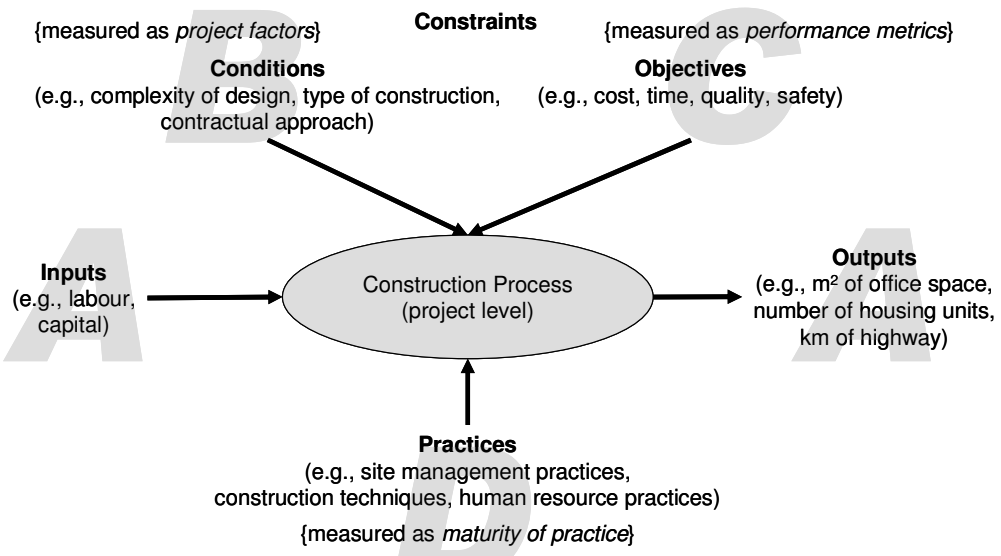

Figure 1: A conceptual model for assessment of the industry (from Fayek et al. 2008).

Safety Management

A more complete review of recent construction safety management research is presented in Goggin and Rankin (2009). The purpose of the review was to establish a set of factors with which

to assess safety management practices. Previous research was generally categorized as focusing on safety climate or safety culture.

To summarize, the definition adopted for safety culture is the attitudes and behaviors exhibited by all members of an organization regarding its health and safety performance (Mohamed 2003). A common theme is the influence senior management has on overall safety culture (Choudry et al. 2008, Jaselskis et al. 1996, O'Toole 2002, and Sawacha et al. 1999). Other notable aspects include the influence of company policies and standards, and employee knowledge and awareness (Guldenmund 2007, O'Toole 2002). Safety climate, is considered to be a gauge of a worker's perception of safety's priority to an organization (Mohamed 2002, Zohar and Luria 2005). The relationship between safety culture and climate is that safety climate reflects the current status of an organization's safety culture (Flin et al. 2000). Safety climate also considers the effect of management's commitment and actions, leadership style (Zohar 2002), and many other project-level specific factors.

The six safety factor groupings identified are: (1) management commitment, (2) policy and standards, (3) worker involvement and commitment, (4) hazard management, (5) equipment, materials, and resources, and (6) working environment. The key references are listed in Table 1 along with the general factor groupings that each addresses.

Table 1: Key references and factor groupings.

Reference; (key topic)	Factor Groupings					
	1	2	3	4	5	6
1. Jaselskis et al. 1996; (safety performance)	✓		✓			
2. Williamson et al. 1997; (safety climate)	✓		✓	✓	✓	
3. Shannon et al. 1997; (injury rates)	✓	✓			✓	✓
4. Sawacha et al. 1999; (safety factors)						
5. Flin et al. 2000; (safety climate)			✓		✓	✓
6. Mohamed 2002; (safety climate)	✓	✓	✓	✓		✓
7. O'Toole 2002; (safety climate and culture)	✓	✓	✓			
8. Trethewy 2002; (workplace safety)	✓		✓	✓		
9. Mohamed 2003; (safety culture)	✓		✓			✓
10. Tam et al. 2004; (site specific safety)	✓		✓		✓	✓
11. Choudry et al. 2007; (safety culture)	✓		✓			
12. Guldenmund 2007; (safety culture and climate)	✓	✓	✓	✓	✓	
13. Choudry et al 2008; (site specific safety)	✓	✓	✓	✓	✓	

Management Practice Maturity

Process maturity modeling, gained its greatest attention in the software manufacturing industry (Finnemore et al. 2000) and is based on the earlier concepts of process improvement such as the Shewhart plan-do-check-act cycle, as well as Philip Crosby's quality management maturity grid which "describes five evolutionary stages in adopting quality practices" (Crosby 1979). Researchers at Carnegie Mellon University used this concept in the development of the Capability Maturity Model (CMM) (Paulk et al. 1995). CMM highlights the five thresholds of maturity which a process must transition through in order to be sustainably improved. Initially a process is (1) chaotic or ad-hoc and must be made (2) repeatable; after which it must be (3) defined or standardized. The process must then be (4) managed, i.e. measured and controlled. Ultimately, the process must be (5) optimized, i.e. it must be continuously improved via feedback and through the use of innovative ideas and technologies. The assessment of the maturity of a process at the organizational level entails determining the extent to which the process is defined, managed, measured and controlled (Dorfman and Thayer 1997); and this is commonly achieved by observing the practices within the organization. A more general definition is that maturity may be viewed as a combination of actions, attitudes, and knowledge rather than constraining the definition to a single set of actions or procedural norms (Andersen and Jessen 2003).

Closer to the construction industry and management of projects are more recent maturity models that include the Project Management Process Maturity (PM)2 Model (Kwak and Ibbs 2002), the Standardised Process Improvement for Construction Enterprises (SPICE) Model (Sarshar et al. 1998), and the related research area of learning organizations in construction (Chinowsky et al. 2007).

The assessment of maturity of safety management practices builds upon previous work on this topic. Willis and Rankin (2009) have defined a maturity model to assess management practices within the construction industry at an industry level. The model uses a three level construct for maturity where a practice is: (1) immature in that it is ad hoc in its application, (2) transitional mature in that it is defined and repeatable, and (3) mature in that it is measured and improved.

Safety Management Practices Framework

By combining the safety factor groupings with the concepts of process improvement and maturity, an assessment framework for safety management practices at the organizational level has been developed. Figure 2 is a conceptual depiction of the framework combined with the approach to implementing it for assessment. The six *factor* groupings are each assessed with respect to the *steps* of plan-do-check-act (PDCA). The assessment is completed through a questionnaire that determines the level of maturity for each *factor–step* couplet. The values of maturity (depicted as radar plots and bars charts) are then available to be used for identifying opportunities for improvement through comparison against other organizations, industry benchmarks, or to measure progress internally. It should be noted that at this time all factors are treated equal as a weighting of factors has not yet been complete.

Safety Factors

Six key safety factors groupings were identified from the literature review, selected due to their applicability at the organizational level, the breadth of information encompassed by them, and their logical influence on construction safety. Limiting the number of factors to six general categories also minimizes the model's complexity. Table 2 is an elaboration of the hazard management grouping, where a general definition of the grouping is provided, followed by a structuring according to the PDCA steps.

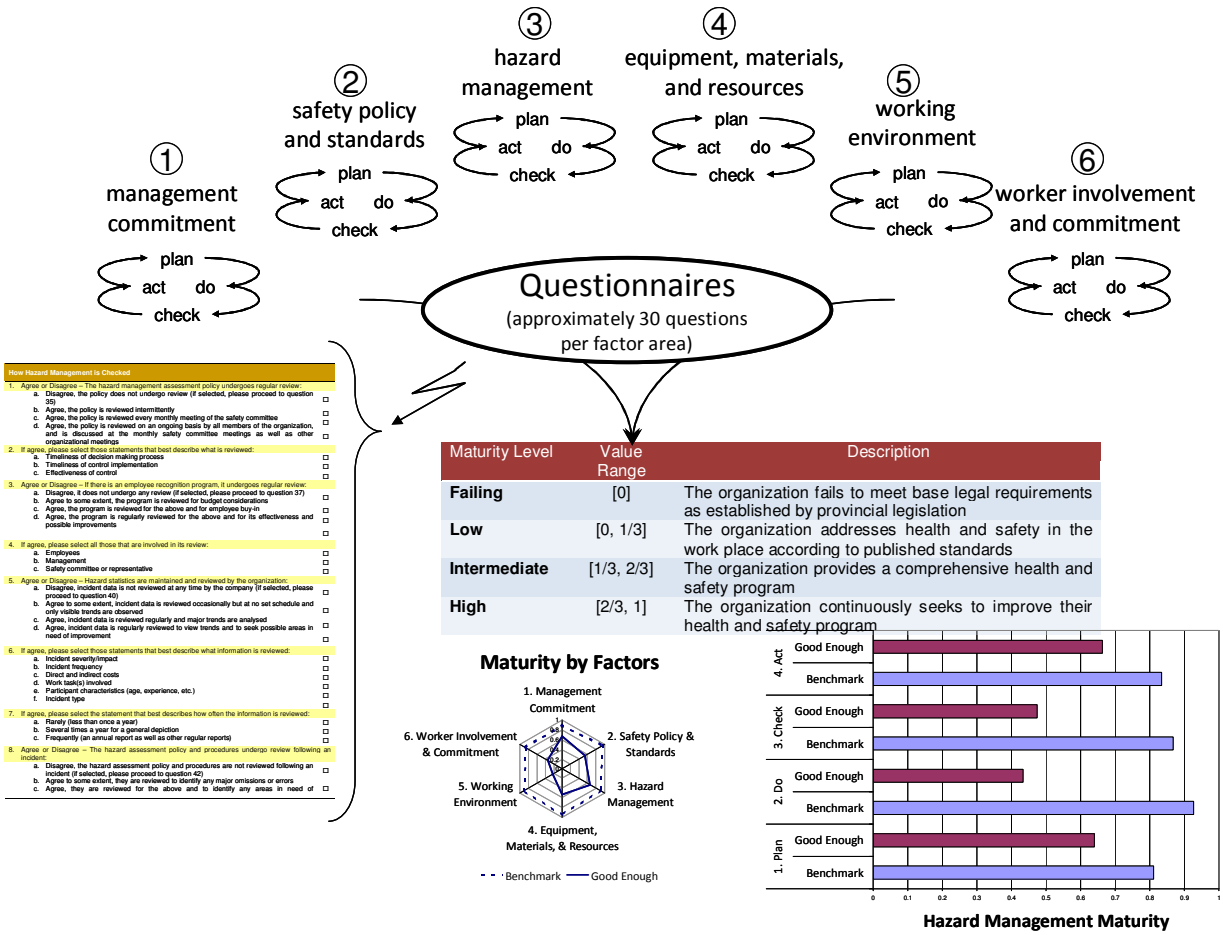

Figure 2: Conceptualized practice assessment framework.

Table 2: Example of elaboration on each grouping through the PDCA cycle.

4. Hazard Management: *This program component is developed predominantly based on the Construction Safety Association's "Hazard Identification and Control" manual as part of their Core Requirements Program. It is considered a planning function as all aspects of the operation are examined and is executed at the organizational level (NBCSA 2008). It focuses on hazard recognition, evaluation, control, and monitoring.*
Plan: Planning of an information management system for the collection, control, and dissemination of hazard data among the organization and its members (e.g. the integration of the reporting process in the organization's policies and standards, the development of distinct guidelines for hazard identification process, and communication of the system's approach and significance to employees). As well, the establishment of a reporting reward system to promote awareness.
Do: Implementation of specific strategies for all members to follow and adhere to, and the communication of identified hazards to employees.
Check: Evaluation of the hazard management program's effectiveness and the reward system's promotional ability.
Act: Adjustments made to the reward system (e.g. removal or modification) and modification of the hazard identification, reporting, and control system for the improvement of overall hazard management.

Levels of Maturity

As previously noted, the safety management maturity scale is restricted to three levels. This minimizes the complexity of the model and aids in the data collection and analysis process. The three levels of the scale are defined as follows:

Level 1 – Low Maturity – The organization fails to meet basic regulatory requirements. Safety is assigned a low priority within the organization and there are few or no formal policies to dictate safety management procedures. Score of 0 - 1/3.

Level 2 – Intermediate Maturity – The organization adheres to base regulatory requirements as established by a governing authority. There are written formal policies to dictate safety management procedures and safety is regarded as a significant factor in project and company performance. Score of 1/3/ - 2/3.

Level 3 – High Maturity – The organization adheres to and exceeds regulatory requirements. Management actively seeks continuous improvement in their safety management procedures and all members of the organization are involved. The written formal procedures undergo regular review. Score of 2/3 - 3/3.

Figure 2 also indicates a *Failing* level of maturity, or a score of 0, in the cases where a factor is related to compliance with legislation. Maturity scores of organizations can then be compared against benchmark values, as represented by the radar diagram and bar chart.

Validation of Practices

The validation of the practices has been partially completed with the input of safety professionals with the New Brunswick Construction Safety Association (NBCSA). A weighting of factors is yet to be completed and is being based on pair-wise comparisons by employing the analytic hierarchy process, where each step within a grouping is weighted and then each grouping of factors is weighted. When completed for a group of experts, the geometric mean of the results will be used to determine the contribution to the maturity scores. This allows for analyses as is presented in Figure 3. The chart is indicating the relative importance associated with each step within the *Hazard Management* grouping of factors along with a maturity score achieved and opportunity for improvement (remaining) at an organizational level. In this illustrative example, the *Plan* factors for

Hazard Management are given a greater weight (0.46 of a total of 1.00) in comparison to the other steps. However, the highest opportunity for improvement for the organization assessed is within the *Act* factors (a remaining value of approximately 0.13). The values of *achieved* and *remaining* are derived with data collected through an organizational questionnaire.

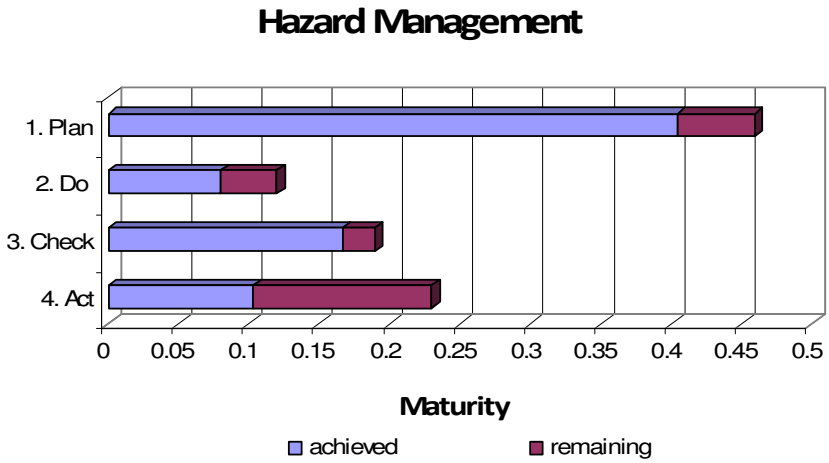

Figure 3: Example of maturity achieved and remaining for weighted PDCA steps.

Data Collection Questionnaire

The questionnaire depicted in Table 3 is an example (*Hazard Management* factor grouping; *Check* step) to demonstrate how information is collected to assess the maturity of safety management practices. The nine questions displayed in the example are from a set of 44 questions for the complete hazard management factor grouping covering all PDCA steps. Each question is structured according to a progression of maturity from ad hoc to continuously improving. The questionnaires are administered by a researcher to a cross section of employees from a given organization (from senior management to on-site workers).

Table 3: Example questionnaire for assessing the *check* step for *hazard management*.

How Hazard Management is Checked	
1. Agree or Disagree – The hazard management assessment policy undergoes regular review:	
a. Disagree, the policy does not undergo review (if selected, please proceed to question 35)	☐
b. Agree, the policy is reviewed intermittently	☐
c. Agree, the policy is reviewed every monthly meeting of the safety committee	☐
d. Agree, the policy is reviewed on an ongoing basis by all members of the organization, and is discussed at the monthly safety committee meetings as well as other organizational meetings	☐
2. If agree, please select those statements that best describe what is reviewed:	
a. Timeliness of decision making process	☐
b. Timeliness of control implementation	☐
c. Effectiveness of control	☐

3. Agree or Disagree – If there is an employee recognition program, it undergoes regular review:
    a. Disagree, it does not undergo any review (if selected, please proceed to question 37) ☐
    b. Agree to some extent, the program is reviewed for budget considerations ☐
    c. Agree, the program is reviewed for the above and for employee buy-in ☐
    d. Agree, the program is regularly reviewed for the above and for its effectiveness and possible improvements ☐
4. If agree, please select all those that are involved in its review:
    a. Employees ☐
    b. Management ☐
    c. Safety committee or representative ☐
5. Agree or Disagree – Hazard statistics are maintained and reviewed by the organization:
    a. Disagree, incident data is not reviewed at any time by the company (if selected, please proceed to question 40) ☐
    b. Agree to some extent, incident data is reviewed occasionally but at no set schedule and only visible trends are observed ☐
    c. Agree, incident data is reviewed regularly and major trends are analysed ☐
    d. Agree, incident data is regularly reviewed to view trends and to seek possible areas in need of improvement ☐
6. If agree, please select those statements that best describe what information is reviewed:
    a. Incident severity/impact ☐
    b. Incident frequency ☐
    c. Direct and indirect costs ☐
    d. Work task(s) involved ☐
    e. Participant characteristics (age, experience, etc.) ☐
    f. Incident type ☐
7. If agree, please select the statement that best describes how often the information is reviewed:
    a. Rarely (less than once a year) ☐
    b. Several times a year for a general depiction ☐
    c. Frequently (an annual report as well as other regular reports) ☐
8. Agree or Disagree – The hazard assessment policy and procedures undergo review following an incident:
    a. Disagree, the hazard assessment policy and procedures are not reviewed following an incident (if selected, please proceed to question 42) ☐
    b. Agree to some extent, they are reviewed to identify any major omissions or errors ☐
    c. Agree, they are reviewed for the above and to identify any areas in need of improvement ☐
    d. Agree, they are reviewed for the above and for areas beyond the incident ☐
9. If agree, please select the statement that best describes the actions that are taken:
    a. The procedures are checked to ensure compliance to legal codes of practice ☐
    b. The above and the procedures are checked to ensure adherence to the current work scope of the organization ☐
    c. The above and the procedures are checked to ensure that all available information sources ☐
    are reviewed regularly for input (e.g. worker experience, past incidents/inspections,
    etc.)

CONCLUSIONS

The framework describes an approach for assessing safety management practices at an organizational level. By combining these with performance data, a relationship can be established. Using the approach of measuring the maturity of safety management practices for different factor groupings and the four steps in a continuous improvement process provides insight as to which areas provide the best opportunities for improvement. Extending the approach to a broader data collection exercise will also facilitate the use of the information collected for industry performance benchmarking and allow normalized comparisons across regions (e.g., provinces or countries). The research described is in a pilot data collection phase where the overall approach has been vetted with industry partners and factor groupings have been partially validated. The immediate steps to follow include completion of the weighting of factor groupings and steps, as well as an analysis of the relationship between practice and performance data.

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