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CSHM: Web-based safety and health monitoring system for construction management

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Abstract

Introduction: This paper describes a web-based system for monitoring and assessing construction safety and health performance, entitled the *Construction Safety and Health Monitoring* (CSHM) system. **Method:** The design and development of CSHM is an integration of internet and database systems, with the intent to create a total automated safety and health management tool. A list of safety and health performance parameters was devised for the management of safety and health in construction. A conceptual framework of the four key components of CSHM is presented: (a) *Web-based Interface* (templates); (b) *Knowledge Base*; (c) *Output Data*; and (d) *Benchmark Group*. **Results:** The combined effect of these components results in a system that enables speedy performance assessment of safety and health activities on construction sites. With the CSHM's built-in functions, important management decisions can theoretically be made and corrective actions can be taken before potential hazards turn into fatal or injurious occupational accidents. **Impact on Industry:** As such, the CSHM system will accelerate the monitoring and assessing of performance safety and health management tasks.

Keywords: Safety and Health Management; Performance Parameters; Performance Assessment; Internet; Database and Knowledge-based Systems

1. Introduction

Safety and health issues at construction sites have gained industry-wide attention, with an increasing number of centers and commissions in different parts of the world promoting construction safety and health. These organizations include the National Occupational Health and Safety Commission in Australia, the Occupational Safety and Health Administration in the United States, the Health and Safety Commission in the United Kingdom, and the Occupational Safety and Health Council in Hong Kong. Many of these organizations are governmental bodies, serving to promote occupational safety and health at work. Their functions include: promoting safety and health in the community; education and training; consultancy services; research and strategies development; and information dissemination (Health and Safety Commission [HSC], 2002; Occupational Safety and Health Administration [OSHA], 2002; Occupational Safety and Health Council [OSHC], 2002). They strive to ensure safe and healthy construction sites, and their efforts have brought about a change of culture among management and front-line workers: from the traditional "not-my-business" attitude to that of "everybody's business" (Levitt & Samelson, 1993).

Meanwhile, academics and professionals are extensively researching occupational safety and health problem areas in the construction industry. These studies can be categorized under three main topics: (a) workers' behaviors and attitudes (Cox & Cox, 1996; Lingard & Rowlinson, 1997); (b) training and workshops (Glendon & McKenna, 1995; Goldenhar, Moran, & Colligan, 2001; Hammer, 1989); and (c) effective management and performance measurement evaluation (Raouf & Dhillon, 1994).

With respect to workers' behaviors and attitudes, the Behavior-Based Safety model (BBS) developed by DePasquale and Geller (1999) has been widely adopted by the industry as the basis for design of safety and health workshops, induction talks, charters, and other safety endeavors. In essence, the model advocates the use of "goal-setting" as a motivational technique to set out the safety goals of the organization and points out the responsibilities of various

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parties accordingly. In addition to bringing about a change of safety culture, previous studies suggested that the BBS model can facilitate interpersonal trust, management support, and active employee participation (Bandura, 1997). While industry training and workshops are useful to kick-start a safety and health campaign, its success, to a large degree, depends on a well-planned site safety and health management system (Elbeltagi & Hegazy, 2002). A typical management system generally consists of three limbs: (a) Goal; (b) Process; and (c) Evaluation. It is at the initial stage when the team sets out 'goals' as to the project policy in relation to safety and health. The team manager then arranges and sets out details of the policy. Throughout the course of construction, regular meetings are held to evaluate performance results, making sure that the standards are met and performance results are consistent with the overall safety and health policy. If the results show the contrary, immediate corrective actions are taken. Such a management arrangement is instrumental in preventing improper behaviors (e.g., insufficient safety precautions, improper working methods, lack of protective gear) that may lead to serious accidents. For this reason, the importance of a safety and health management system, in particular the measurement and evaluation of performance, cannot be over-emphasized.

Despite the vast volumes of work on safety and health management, most are concerned with the first two limbs: (a) *Goal* (how to set up project goals) and (b) *Process* (how to implement a management system). A lot of work has been done on the value and culture of safety management systems (Krause, 1993; Smallwood, 2002). Others turn to the actual implementation of safety and health management systems, such as the opportunities/benefits provided (Ray & Rinzler, 1993) and the barriers encountered (Hinze, 1997; Levitt & Samelson, 1993). There is relatively little work done in relation to the third limb *Evaluation*; that is, the systematic measurement and assessment of performance (safety and health efforts and results; Geller, 1998). McAfee and Winn (1989) and Cooper, Philips, Sutherland, and Makin (1994) recommended the use of incentives and performance assessment to enhance workplace safety. In their studies, empirical results suggested that systematic measurement and assessment of performance is a useful device to improve safety conditions and reduce accidents. Several possible methods to measure whether the efforts made were effective and whether the performance results have been met to satisfy the safety objectives, include checklists, inspections, attitude surveys, walk-throughs, and document and record analysis (Haupt, 2002).

This paper demonstrates that the process of taking performance measurement can be streamlined through integration with database, web, and expert systems. The paper focuses on the design and development of a prototype of a web-based safety and health monitoring system. In fact, there have been successful applications of web and database technologies in other areas of construction management; for instance, the use of *QUALICON* in construction quality management (Battikha, 2002), the *Partnering Temperature Index* in measuring both "soft" and "hard" management issues (Cheung, Suen, & Cheung, submitted for publication), the *Risk Register Database* in managing project risks (Patterson & Neailey, 2002), and the measuring of cost and quality (Construction Industry Institute [CII], 1989).

2. Aims and Objectives

This paper describes the design and development of a prototype web-based safety and health monitoring system for construction projects—Construction Safety and Health Monitoring (CSHM). CSHM can be used as a detector of potential risks and hazards and, more importantly, a warning sign to areas of construction activities that require immediate corrective action. The ability to identify safety and health hazards as early as possible is vital to a project of any size and scale because "prevention is always better than cure" (Nikander & Eloranta, 1997). It is anticipated that CSHM can facilitate speedy safety and health management. However, CSHM is not intended, in any way, to replace the current practice of safety and health management. Instead, it adopted the Safety and Heath Management Model (OSHC, 2002) as the basis for its system design. To make good use of the advent of IT and database technologies, all of the functions of CSHM were designed to be web-based, thus enabling remote access, speedy data collection, retrieval, and documentation. Furthermore, a *Knowledge Base* was included in the design to enable online expert advice and instructions. In achieving this, the major objectives are as follows:

- Developing a **Web-based Interface** for management and assessment of data related to safety and health performance. The interface should enable automated collection, measurement, assessment, storage, and presentation of data;
- Developing an exclusive ***Knowledge Base*** for Safety and Health Management. That is, rules, guidelines, best practices, and so forth, for the prevention and resolution of hazards and unconfirmed practices. These are derived from the practical experience of experts and professionals in the field;
- Developing a portal to handle key **Output Data** in a systematic manner. For instance, key and operational data are separated automatically through preset functions such that only data of great importance (i.e., total fatal incidents per month) to senior management are summarized into the executive summary report. Data of less importance, such as those related to operation activities, are stored in the project report; and;
- Setting up a framework for the design of **Benchmark Groups**. Organizations or parties interested in knowing more about the industry "benchmarks" or "standards" in