

Framework for Measuring Corporate Safety Culture and Its Impact on Construction Safety Performance

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Abstract: This paper presents the results of a structural equation model (SEM) that describes and quantifies the relationships between corporate culture and safety performance. The SEM is estimated using 196 individual questionnaire responses from three companies with better than average safety records. A multiattribute analysis of corporate safety culture characteristics resulted in a hierarchical description of corporate safety culture comprised of three major categories—people, process, and value. These three major categories were decomposed into 54 measurable questions and used to develop a questionnaire to quantify corporate safety culture. The SEM identified five latent variables that describe corporate safety culture: (1) a company's *safety commitment*; (2) the *safety incentives* that are offered to field personal for safe performance; (3) the *subcontractor involvement* in the company culture; (4) the field *safety accountability* and dedication; and (5) the *disincentives* for unsafe behaviors. These characteristics of company safety culture serve as indicators for a company's safety performance. Based on the findings from this limited sample of three companies, this paper proposes a list of practices that companies may consider to improve corporate safety culture and safety performance. A more comprehensive study based on a larger sample is recommended to corroborate the findings of this study.

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Introduction

Great strides towards a safe workplace environment have been made in the construction industry. The majority of large construction companies have comprehensive safety plans, but the quality of the plan does not necessarily correlate to a company's safety performance. Written safety plans have the potential to be very effective, but companies must go beyond the safety plan and create a true "safety culture" (Hinze 1997). It is the premise of this research that individual corporate safety cultures have as much, or more, to do with the safety performance than the safety plan. This research identifies corporate safety culture characteristics that correlate to safety performance.

It is hypothesized that corporate safety cultures by their very nature cultivate successful safety programs. While this hypothesis seems intuitive, little research has been conducted to specifically identify and measure critical cultural characteristics that influence safety. This research attempts to quantify the relationship between corporate culture and safety performance. Using 196 questionnaire responses from three construction companies with above average safety records, statistical relationships between corporate

culture and safety performance are revealed through a series of five latent variables that describe corporate safety culture. Data were collected from a fourth company but not included in the analysis as explained in the data collection section of this paper.

Defining corporate safety culture is a complex task. This research began by decomposing corporate safety culture into measurable attributes using a multiattribute analysis technique pioneered by Miller (1970). Through expert interviews and an exhaustive literature review, a multiattribute hierarchy of corporate safety culture was defined. The highest level of the hierarchy decomposed corporate safety culture into three principal categories of people, process, and values. These three categories were then subdivided and decomposed into 54 measurable questions that formed the basis of a questionnaire to measure corporate safety culture. From data collected in the questionnaire, a structural equation model (SEM) was estimated to identify latent characteristics that describe safety culture and to quantify relationships between them. Examination of the resultant SEM revealed five latent variables that describe corporate safety culture: (1) a company's *safety commitment*; (2) the *safety incentives* that are offered to field personal for safe performance; (3) the *subcontractor involvement* in the company culture; (4) the field safety dedication and *safety accountability*; and (5) the *disincentives* for unsafe behaviors. These areas of company safety culture can be used as indicators for a company's safety culture performance.

This paper begins by presenting the definition of corporate culture in relation to safety and then briefly describes the multiattribute hierarchy used to measure corporate safety culture. A detailed description of the data collection and modeling are presented as a basis for the presentation of the SEM findings. Latent variables that describe corporate safety culture are discussed. A practical application of the results is presented in the form of best practices that other companies can use to improve their corporate safety culture. The paper concludes with a discussion of limita-

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tions of the research stemming from the limited data collection in the study.

Corporate Culture

This research began with a review of previous safety culture research. However, it was quickly discovered that there was no common definition of corporate culture in safety research. A generic definition of corporate culture is helpful in the understanding of corporate safety culture. Hampden-Turner (1990) define corporate culture as “a pattern of basic assumptions invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration that has worked well enough to be valid and to be taught to new members as the correct way to perceive, think, and feel in relation to these problems.” Corporate culture is a collection of uniform and enduring beliefs, customs, traditions, and practices that are shared and continued by the employees of a corporation (Hai 1986). These shared beliefs define the fundamental characteristics of an organization and create an attitude that distinguishes one organization from all others (Maloney and Federle 1990). It is the unique configuration of norms and behaviors that characterize the manner in which employees combine to accomplish tasks (Graves 1986). Corporate culture refers to the values held by employees of an organization that tend to persist even when membership changes (Kotter and Heskett 1992).

Corporate culture is instrumental in an organization's success. It provides the workplace environment for the employees of an organization. When people work in an environment that they perceive as rewarding, they are more likely to perform at a high level. Furthermore, a company's success is the result of the organization performing certain tasks very well (Maloney and Federle 1990). Corporate culture is what determines these work environments, as well as the tasks in which an organization excels.

The definition of corporate culture is complex when all of the facets above are considered. For purposes of this study, corporate culture is defined as the *beliefs, values, and behaviors that are consistent throughout all members of the corporation*. These beliefs, values, and behaviors must be consistent throughout upper management, middle management, and field employees. For a further definition of corporate safety culture see Molenaar et al. (2002).

Multiattribute Hierarchy

Measurement of corporate safety culture is a complex task. Employing multiattribute analysis, this problem can be decomposed into three main categories—people, process, and values. People are integral to defining the cultural characteristics of a corporation. They determine the beliefs, values, and behaviors that create a corporation's culture. The second category, process, is the manner in which a company incorporates safety into practice. A good “safety process” is necessary for a company to properly communicate its safety goals. Finally, values are the philosophy of the company in regard to safety. This category determines whether employees believe that safety is a high priority of their company. The subcategories for each of these three categories are defined in the following paragraphs.

People

Role of Top Management

Management both creates and controls the environment in which construction accidents occur (Smallwood 1996). This section measures the level to which management acknowledges the significance of a safety program and becomes involved in the safety process.

Role of Field Personnel

Employees in field operations can benefit the most from safe conditions. This section measures field personnel's commitment to the safety program and involvement in the process.

Subcontractor Relationship

Subcontractors are often an integral part of construction projects and can have a direct bearing on company safety. This section measures subcontractors' involvement in the process and commitment to the safety program.

Process

Safety Plan

The safety plan is an integral part of a company's safety practice. The company can clearly delineate its safety goals through the preparation of an effective safety plan. This section measures the attributes of the safety plan.

Assessment and Change of the Safety Program

Safety programs are often in a state of constant change and improvement. This section measures the process of assessment and change of the safety program.

Safety Training and Education

Safety training and education are integral to teaching safe behaviors and to providing feedback on the effectiveness of current safety procedures. This section measures the level and frequency of the safety training.

Safety Incentives

Safety incentives are defined as any gifts or rewards that are given out on a regular basis. This can be a variety of rewards from points to earn company merchandise to actual cash or cash equivalents. This section measures the company's use of incentives to improve safety performance.

Disincentives

A disincentive is any form of punishment. It can be anything from an oral reprimand, to a written reprimand, to garnishment of wages or termination of employment. This section measures the company's use of disincentives for unsafe behaviors to improve safety performance.

Values

Safety Commitment

A commitment to safety reflects a core value of a company. This section measures the commitment to safety as reflected in core values of a company.

Safety is a strategic concern of top management.

Disagree Agree
1 2 3 4 5 6 ☐ Cannot
 answer

Fig. 1. Example of questionnaire format

Behavior-Based Safety

This form of safety encourages behavior modification. Behavior modification attempts to change unsafe behaviors into safe behaviors by involving everyone in the organization. This section measures the level of behavior-based safety practices in the company.

The three major categories defined above with their corresponding subcategories were broken down further into 54 measurable questions to define corporate safety culture. The framework of the questionnaire is discussed in the following section describing the research methodology and the questions that proved to be significant indicators of corporate safety culture are discussed in the results section of this paper.

Research Methodology

Data Collection

A survey methodology was selected to collect data regarding company culture because it offered the best opportunity to capture a cross section of the beliefs, values, and behaviors in multiple companies in a timely and efficient manner. A comprehensive literature review was performed to discover corporate characteristics that might influence safety culture. These characteristics were then organized into a hierarchical structure and decomposed into measurable characteristics using rigorous multiattribute techniques (Miller 1970), as previously discussed. A questionnaire was then developed from the multiattribute hierarchy through tested survey and attitude measurement procedures (Oppenheim 2001). The final questionnaire that was used to measure corporate safety culture was comprised of 54 questions. Where the questions could be precisely measured (i.e., average term of employment), absolute scales were employed. However, the majority of the questions involved subjective measurements, and a Likert scale (i.e., 1=never and 6=always) was employed; see Fig. 1.

Data from four companies with outstanding safety records were collected in this research. These four were selected because they share many common traits. They are all national firms that have a large office based in the Denver, Colorado area; they all perform some of their own work (such as carpentry, concrete placement, and some masonry work); they all primarily concentrate on large commercial buildings; and all were willing to actively take part in data collection. Finally, all of these companies have outstanding safety records as measured by their experience modification ratio (EMR) and recordable incidence rates (RIR).

From this point forward, the companies taking part in this study will be referred to as Company "A," "B," "C," and "D" in no particular order. Over 800 questionnaires were distributed to the companies through payroll mailings and at safety meetings. A total of 237 questionnaires were returned—Company A (44), Company B (39), Company C (129), and company D (25). The information was collected and input into a database and for modeling. However, 41 questionnaires were determined to be outliers including 19 of the 25 questionnaires from the fourth company. Prior to modeling, it was determined that data from the fourth company and the remaining 12 outliers should be discarded. A total of 196 questionnaires from the three companies are analyzed

in this study. Overall survey response rates as well as the overall response rates within companies are displayed in Figs. 2 and 3.

Fig. 2 describes the overall survey response. Company C represents the largest portion of the sample because it was the biggest of the three companies and also had the greatest proportion of employees responding. As seen in Fig. 3, between 24 and 43% of the employees from each company completed the questionnaire. Field personal, middle management, and upper management all completed the questionnaire. Overall, the data set accounts for a reasonable representation of the three companies participating in this study and produces statistically significant results as described later in this paper. The limitations section of this paper discusses the advantages and challenges to including more companies in the data collection.

EMR and a series of RIRs were gathered as measures of safety performance from the three companies. EMR and RIR are common measures of safety performance. To determine the most appropriate measure of company safety, a regression analysis was performed on the data using EMR and RIR as dependent variables. R^2 and the corresponding significance level of the F -ratio were used as goodness of fit measures for the models. EMR resulted in a superior indicator of safety performance and is used as the safety performance measure throughout the remainder of this study. Although regression analysis was not determined to be the best tool for final analysis, the results were sufficient to make a sound choice between EMR and RIR as dependent variables.

Structural Equation Modeling

Although multiple regression analysis has most commonly been used to find indicators of safety performance (Jaselskis et al. 1996), SEM was selected as the analytical tool to measure the affect of company culture on safety performance (Washington et al. 2003). In this case, regression analysis will have two significant problems. First, safety culture is made up of many unobserved, or latent variables and these variables are likely to be interrelated. A fundamental premise of multiple regression analysis is that all variables are assumed to be independent. In the case of modeling corporate culture, there will likely be problems of multicollinearity caused by the interdependency between inde-

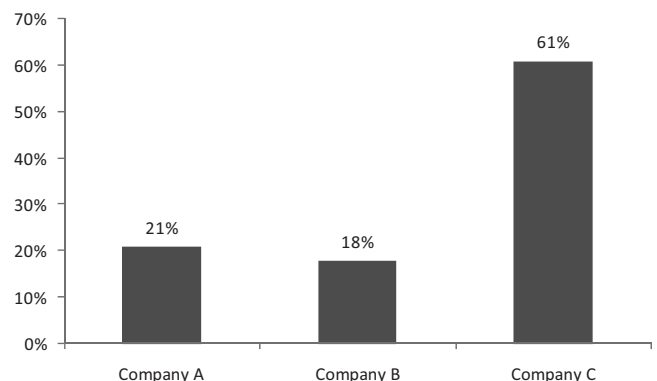


Fig. 2. Overall company response

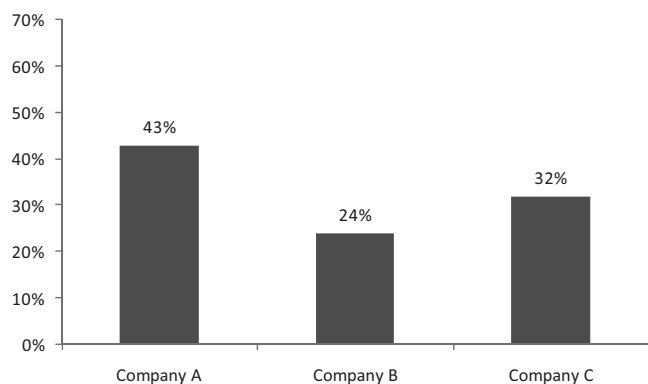


Fig. 3. Overall response within companies

pendent variables. The second problem is that standard multiple regression techniques ignore measurement error. There is inherent measurement error in survey data of this type, stemming both from inaccurate ratings on a Likert scale and inconsistent responses to quantitative replies. When measurement errors in independent variables are incorporated into a regression equation (via a poorly measured variable) in standard fashion, the variances of the measurement errors in the regressors are transmitted to the model error, thereby inflating the model error variance (Myers 1990). In other words, measurement errors will result in greater estimated model variances and measurement errors in independent variables can cause irreconcilable technical problems.

The standardized coefficients in a SEM can possess more reliable estimates of how an exogenous variable affects an endogenous variable than what is produced with multiple regression analysis. There are two basic premises in SEM to overcome these problems of multiple regression analysis. First, SEM typically incorporates the covariance matrix of the independent and dependent variables. It uses a maximum likelihood estimation procedure to derive the “most likely” coefficient values, given the actual covariance matrix. The second premise is that SEM establishes the relationships between unobservable—termed latent variables and attempts to account for random measurement error that cannot be employed by multiple regression analysis.

SEM has two main model components, a measurement component and a structural component. The measurement model describes how well various exogenous variables measure latent variables, as described previously. A classical factor analysis is a measurement model, and determines how well various variables describe a factor or factors, or latent variables. The measurement models within a SEM incorporate estimates of errors of measurement of exogenous variables and their intended latent variable.

The second component of a SEM is the structural component. The structural model describes the relationships between latent variables. SEM allows for direct, indirect, and correlative effects to be explicitly modeled, unlike standard regression models, which allow only for explicit modeling of direct effects. It is the structural component of SEM that enables the analyst to make substantive statements about the relationships between latent variables, and the mechanisms underlying a process or phenomenon. The structural component of SEM is akin to a system of simultaneous regression models. Please refer to Molenaar et al. (2000) for a more comprehensive description of SEMs and their application to construction engineering and management problems.

Research Results

Numerous iterations were performed to arrive at a final SEM specification shown in Fig. 4. The observed or measured exogenous variables—responses to survey questions—are shown in the rectangular boxes in Fig. 4. The unobserved latent variables are shown in ellipses and represent the critical characteristics of

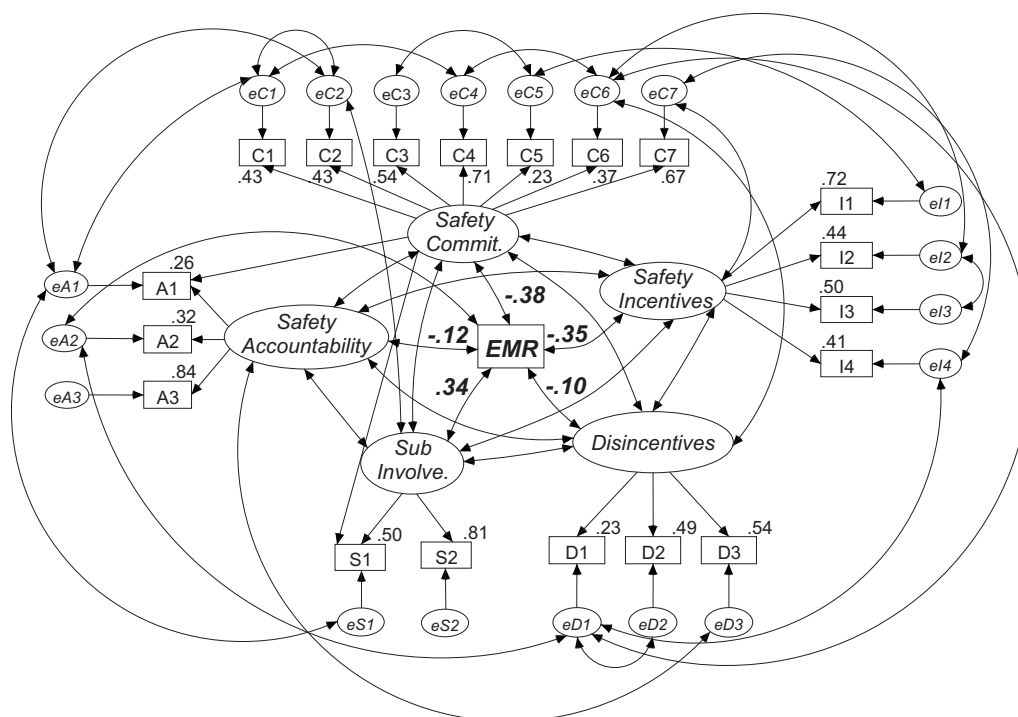


Fig. 4. Standardized SEM of safety culture performance

Table 1. Overall SEM Model Results

Description	Result
Number of parameters estimated	96
Degrees of freedom	134
Chi square at model convergence	174.69, probability <0.010

corporate safety culture, which cannot be directly observed. The arrows shown in Fig. 4 represent the direction of hypothesized influence. For example, the straight single arrows connecting *safety commitment* to the seven exogenous variables (C1 to C7) are presumed to be the underlying mechanism that produced the outcomes of the observed variables (please note that the survey questions have been renumbered to correspond with the latent variables for clarity as described below). Similarly, the other sets of questions are thought to reflect the influence of *safety incentives*, *safety accountability*, *subcontractor involvement*, and *disincentives* latent variables on survey responses. The curved double-headed arrows linking the exogenous variables to each other represent the fact that these exogenous variables are correlated. The numbers near the straight arrows are the standardized correlation coefficients obtained when an endogenous variable is regressed on the set of exogenous variables to which it is functionally related and the numbers by the curved arrows are the standardized correlation coefficients between each of the variables. A larger number can be considered a better indicator of the latent variables.

Before the SEM analysis began, a rough estimate of the latent variables was derived from a factor analysis. A factor analysis is a tool used to discover underlying dimensions that account for patterns in variation among observed variables. Underlying dimensions imply ways to combine variables, in this case, aspects of safety culture, thereby simplifying subsequent analysis (Hamilton 1992; SPSS 2001). A factor analysis using the varimax rotation method with Kaiser normalization was utilized. The rotation converged in 10 iterations.

The initial SEM was constructed using various combinations of the factor analysis results and then model improvements were performed using a combination of modification indices (Hoyle 1995) and solid theoretical support until a final satisfactory model was identified. In essence, asymptotic *t*-statistics and R^2 goodness of fit (GOF) measures are employed to assess the regression equations in the model.

The resultant five latent variables account for about 55% of the variability in EMR (mean estimate of 0.55 and standard error = 0.005). Recall that a lower EMR correlates to better safety performance, so a negative standardized correlation coefficient cor-

relates to better safety performance. The overall SEM model results are given in Table 1 and the goodness of fit measures are given in Table 2.

It may be surprising that the model presented was the best-fitting model selected from many competing models that were fit to the data, all of which had solid theoretical support for their estimation. The chi-square value at model convergence indicates a poor model fit. Associated with the chi square is the probability that the data were observed if the model were indeed well fitting, a low probability OF <1%. However, by taking into account the numerous other GOF measures for the SEM model, the model depicted in Fig. 4 is a well-fitting model of EMR and safety culture. The equivalent of the R^2 for the overall model ranges from 0.98 to 0.99, depending on the GOF criteria, the root mean squared error of approximation (RMSEA) is 0.039, where 0.05 cannot be rejected at a high level of confidence, and all other GOF measures are encouraging. Despite chi-square value and associated probability, the SEM appears to be a theoretically and statistically defensible model.

Both the measurement and structural components of the SEM provide insight into the influence of company culture on safety performance. The measurement portion of the latent variables and structural portion of the SEM are discussed in the following sections.

SEM Measurement Component—Description of the Latent Variables

The measurement component of the SEM describes how accurately the various exogenous variables measure latent variables. The measurement models within a SEM incorporate measurements of exogenous variables with their associated errors to their corresponding latent variable. The final five latent variables discovered to directly influence safety performance are presented below. The latent variables are discussed in their order of influence on EMR in the following sections of the paper. A more detailed interpretation of the latent variable effects on EMR and their correlation to the other variables is presented in the following section of the paper describing the structural component of the SEM.

Safety Commitment

A company's *safety commitment* influenced the responses to seven questions on the survey questionnaire. These variables span across multiple branches of the multiattribute hierarchy. Five of the seven observed variables that comprise *safety commitment* were extracted from the value branch of the multiattribute hierarchy. The other two, *management commitment* and *strategic con-*

Table 2. Overall SEM Model Results: Goodness-of-Fit Measures [for Additional Information on Goodness-of-Fit Measures, See Arbuckle (1997)]

Goodness-of fit-measure	Description of test	Saturated model (best case)	Final model	Independence model (worst case)
Number of parameters	Parameters estimated	230	96.0	20
Tucker-Lewis index (TLI)	0 (no fit) to 1 (perfect fit)	1.000	0.996	0.000
Normed fit index (NFI)	0 (no fit) to 1 (perfect fit)	1.000	0.988	0.000
Root mean squared error of approximation (RMSEA)	<0.05 indicates very good fit	n/a	0.039	0.595
Akaike information criterion (AIC)	0 (perfect fit) to positive value (poor fit)	460	367	14,748
Browne-Cudeck criterion (BCC)	imposes a larger penalty than AIC for complex models: lower numbers means better fit	516	390	14,753

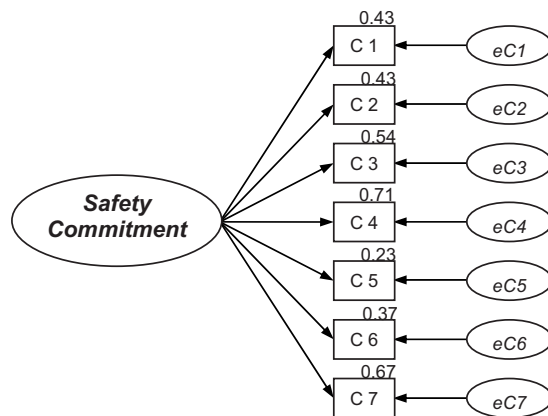


Fig. 5. Safety commitment

cern about safety, are found in the people branch; however, all seven variables share the common thread of the company's commitment to safety. The variable that measures if the actions of the company portray a true commitment to safety has highest squared multiple correlation (0.71). This can be interpreted as meaning that 71% of the variability in the observed variable can be explained by the latent variable, *safety commitment*, and the remaining 29% of the variability is unaccounted for and included in the error term. *Hazard prevention* (0.67) and *importance of safety* (0.54) are the next two most highly correlated variables.

The graphical representation of the latent variable and its components is shown in Fig. 5. The numbers above the observed variables are the squared multiple correlations. As previously described, *safety commitment* explains about 71% of the variability in C4, and eC4 explains other portions.

The definitions of the observed variables are provided in the following list. Recall that all of the observed variables were originally identified by literature review and are referenced accordingly:

- *Management commitment* (C1): the importance that management places on safety, as well as whether or not safety is of a strategic concern to the well being of the company ("Fluor Daniel . . ." 1997);
- *Strategic concern* (C2): the level at which management initiates safety concerns (Lo 1996);
- *Importance* (C3): the importance of safety to the company (Groover and Krause 1993);
- *Actions* (C4): whether or not the actions of the company portray a true commitment to safety ("Fluor Daniel . . ." 1997);
- *Responsibility* (C5): how the company defines safety responsibility. If it is the responsibility of safety personnel only or if it is everyone's responsibility (Preston and Topf 1994);
- *Identified and corrected* (C6): how often unsafe behaviors are identified and corrected (Hodson and Graham 1998); and
- *Hazard prevention* (C7): the level of importance that is placed on hazard analysis, prevention, and control (Hodson and Graham 1998).

Safety Incentives

Safety incentives that are offered to personnel for safe performance correlate to better safety performance. In this latent variable, *safety incentives* can take the form of performance feedback in the safety program and an understanding that employees will be thanked for performance, or *safety incentives* can take the more traditional form of money and merchandise. Fig. 6 quanti-

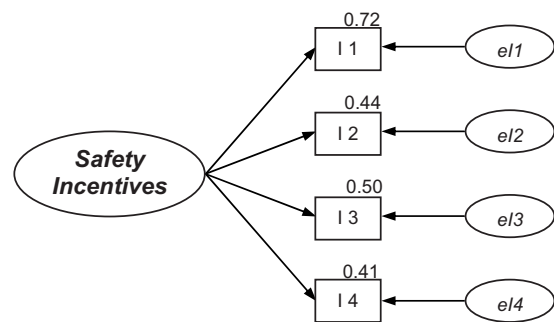


Fig. 6. Safety incentives

fies these relationships. Here, *feedback* in the safety program (0.72) and *frequency* of incentives (0.50) are best explained by this latent variable. All components of the *safety incentives* latent variable are extracted from the process branch of the multiattribute hierarchy. Fig. 6 depicts the *safety incentives* latent variable and the observed variables are defined as follows:

- *Feedback* (I1): the amount of feedback involved in the safety program. This includes management to personnel, personnel to management, and peer-to-peer feedback (Garis 1998) and (Hofmann 1996);
- *Understanding of being thanked* (I2): understanding with field personnel that they will be thanked for their safe performance (Gibb and Foster 1996);
- *Frequency* (I3): how often incentives are given to employees. This includes field personnel as well as management (Garis 1998); and
- *Value of incentives* (I4): how valuable the employees believe that the incentives are (Gibb and Foster 1996).

Subcontractor Involvement

The third latent variable, *subcontractor involvement*, captures the involvement of subcontractors with the company's culture. It is comprised of only two observed variable, which are found in the people branch of the multiattribute hierarchy. The *importance* that the subcontractors place on safety and the subcontractors' frequency of *attendance* at safety meetings and training are influenced by the *subcontractor involvement* variable as seen in Fig. 7 and described in the following list:

- *Importance* (S1): the level of importance that typical subcontractors place on safety (Gibb and Foster 1996); and
- *Attendance* (S2): how often subcontractors are required to attend safety meetings and training (Gibb and Foster 1996).

Safety Accountability

Safety accountability and dedication is the fourth latent dimension of corporate safety culture. Like the *subcontractor involvement* latent variable, the components of *safety accountability* were found in the people branch of the multiattribute hierarchy. *Assigned accountability* has the highest squared multiple correlation (0.84) and is most influenced by *safety accountability*. The fol-

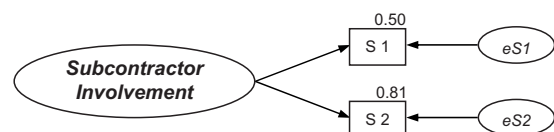


Fig. 7. Subcontractor involvement

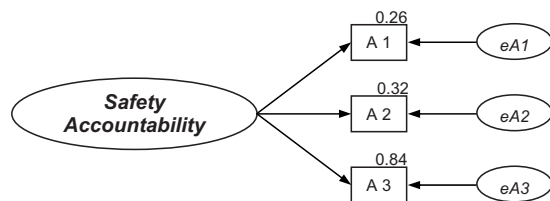


Fig. 8. Safety accountability

lowing are the observed variables that comprise *safety accountability*, which is graphically depicted in Fig. 8:

- *Importance* (A1): the level of importance field personnel and site managers place on safety (Meijer and Schaefer 1996);
- *Dedicated* (A2): how often dedicated safety personnel are used in the field, as well as how often they observe and correct field personnel (Jaselskis et al. 1996); and
- *Assigned accountability* (A3): whether or not management assigns specific safety accountability to individuals (Smallwood 1996).

Disincentives

The last latent variable involves *disincentives* for unsafe behaviors. Poor safety practices should not be ignored; however, this method must be accompanied by review and feedback (Hartshorn 1998). In this study, the two most highly correlated observed variable stem from the *consistency* of punishments that are implemented (0.49) and the *enforcement* of safety rules (0.54), even when no accident has occurred. All components of this latent variable are extracted from the process branch of the multiattribute hierarchy and are represented in Fig. 9:

- *Understanding* (D1): understanding with field personnel that they will be reprimanded for their unsafe performance (Hartshorn 1998);
- *Consistency* (D2): the consistency of the supervisory personnel of the company when punishing for rule violations. It also takes into consideration the severity of the punishment as compared to the severity of the violation (Hartshorn 1998); and
- *Enforcement* (D3): the degree to which safety rules are enforced when no accident occurred, but a safety violation took place. It also considers how often displays of sympathy occur during disciplinary action ("Fluor Daniel..." 1997).

SEM Structural Component—Description of Corporate Safety Culture

The structural component of the SEM explains the relationships between latent variables. SEM allows for direct, indirect, and correlative effects to be explicitly modeled, unlike standard regression models, which allow for explicit modeling of direct effects only. Fig. 10 displays the structural component of the SEM. In

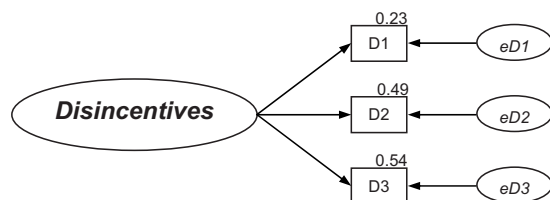


Fig. 9. Disincentives for unsafe behaviors

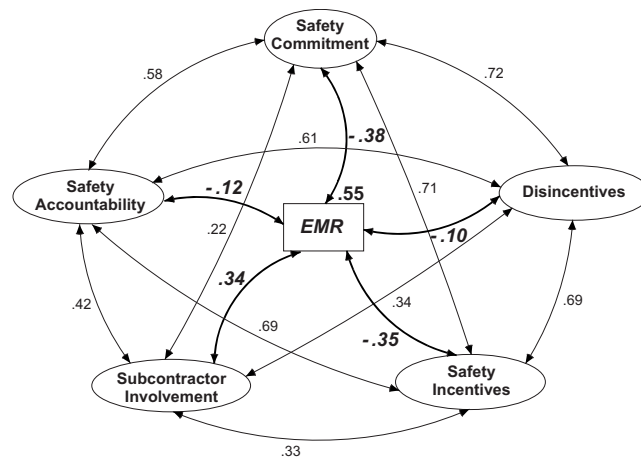


Fig. 10. Structural component of SEM with correlation among variables shown

this model, all latent variables are found to be somewhat correlated with EMR, as well as all being correlated with each other.

Safety Commitment

Recall that the SEM accounts for 55% of the variability in EMR as modeled through the data collected in this study. The company's *safety commitment* to the safety program has the greatest influence on safety performance. The standardized correlation coefficient between *safety commitment* and EMR is -0.38 . The negative correlation can be interpreted as meaning that an improvement in the company's commitment to safety correlates to an increase in company safety performance as measured through a decreased EMR value. The structural component of the SEM also describes how this commitment relates to other variables. In this study, the *safety commitment* variable is highly correlated with the *disincentives* variable (0.72) and the *incentives* variable (0.71), which can be interpreted as meaning that a company's commitment is shown through punishment for unsafe behaviors and offering incentives for safe performance.

Safety Incentives

Safety incentives, as previously described, are also highly correlated to safety performance as measured through EMR in this study (standardized correlation coefficient of -0.35). *Safety incentives* have been proven to increase safety performance (Garis 1998; Gibb and Foster 1996), and this study confirms that fact for the three companies studied. Not surprisingly, the *safety incentives* and *disincentive* latent variables are highly correlated (0.69). However, it should be noted that combining these variables resulted in a model that was slightly less well fitting. There has been much debate over the application of incentives or disincentives to improve safety performance (Gambatese 2001). This study shows that *safety incentives* (-0.35) have a greater effect on safety performance than do *disincentives* (-0.10) for the three companies studied. In fact, removing *disincentives* from the model did not greatly reduce the overall explanatory power of the model, but *disincentives* were kept in the model because of their high correlation with the other latent variables. Of interest also is the high correlation of the *safety accountability* variable with both the *safety incentives* (0.69) and *disincentives* (0.61). Both *safety incentives* and *disincentives* can play a role in field dedication and accountability.

Subcontractor Involvement

The third latent variable describes the involvement of *subcontractor involvement* in the company's culture. The *subcontractor involvement* variable is the only variable that adversely affects EMR as measured through the survey (standardized correlation coefficient of 0.34). Gibb and Foster (1996) found that subcontractors have a significant bearing on safety. Subcontractors can be relatively independent from a company and can create challenges in improving a company's safety record (Meijer and Schaefer 1996). As written in the questionnaire, it was expected that a greater level of importance placed on safety by the subcontractor and more frequent attendance to safety meetings would result in better safety performance, but the results were just the opposite. Upon further review of the data, it was found that the company with the highest level of self-performed work had the best safety culture performance. As previously described, during the data collection phase of this study, a fourth construction company was selected for analysis. They were selected because they worked in the same region, building sector, and had approximately the same construction volume as the other three companies. However, it was revealed that they subcontracted the majority (almost exclusively) of their work. The fourth company also had the highest EMR, which corresponds to the worst safety performance. A conclusion that can be drawn from these limited results is that increased use of subcontractors adversely affects safety culture. A consistent culture might only be developed over years of work with the same employees. This is an area in need of further study.

Safety Accountability

The *safety accountability* variable is not the best indicator of safety performance but it is somewhat correlated (-0.12). The use of dedicated field safety representatives would appear to be effective for improving safety performance (Duff et al. 1994; Jaselskis et al. 1996). The *safety accountability* variable is also highly correlated with the *safety commitment* (0.58), *safety incentives* (0.69), and *disincentives* (0.62) latent variables. While *safety accountability* may not have a strong direct relationship to EMR and safety performance in this study, its indirect relationships help to explain the other more strongly correlated values. The importance of the *safety accountability* variable as described through the measurement component of the SEM and through its relationships with the other variables in the structural component of the SEM should not be excluded.

Disincentives

The last variable involves *disincentives* for unsafe performance. Similarly to the *safety commitment* variable, *disincentives* has only a mild correlation with EMR and safety performance (-0.10). However, the *disincentives* variable is highly correlated with *safety incentives* (0.69). As previously discussed, *safety incentives* have much higher correlation coefficient with EMR and serve as a better indicator of safety performance, but *disincentives* do add explanatory power to the model.

Conclusions and Recommendations

Corporate safety culture is extremely complex to define and measure as displayed through both the multiattribute hierarchy and the multiple interrelationships of the SEM estimated in this research. However, the SEM and the latent variables it describes constitute a powerful framework for defining, measuring, and improving

upon corporate safety culture. Analysis of data from the 54 measurable characteristics revealed that 19 could be used to describe a final set of five latent variables. These five latent variables can be considered characteristics of corporate safety culture and may be used as indicators of safety performance as measured through EMR.

This SEM suggests that corporate safety culture is an important aspect of safety performance. The five characteristics described by the latent variables in the SEM may be interpreted as action items that companies can use to improve their corporate safety culture and their safety performance. Each latent variable can be summarized as a corporate safety culture characteristic with corresponding action items that may improve safety performance as follows:

Increase a company's *safety commitment*:

- Make safety a strategic concern;
- Actively participate in safety;
- Assign safety responsibilities at field levels, not just safety personnel;
- Identify and correct unsafe behaviors before they result in accidents; and
- Offer meaningful incentives for safe performance.

Offer *incentives* to personnel for safe performance:

- Offer opportunities for all personnel to provide feedback regarding safety concerns;
- Create an understanding that field employees will be thanked for safe performance;
- Increase the value of incentives; and
- Increase the frequency of incentives.

Integrate *subcontractors* in the company's culture if it is not possible to self-perform work:

- Encourage the use of companies who self-perform work; and
- Create long-term relationships with subcontractors.

Clearly assign *accountability* and dedicated field safety representatives:

- Clearly assign accountability at field levels;
- Allocate full-time safety representatives on site; and
- Make site managers commit to the safety.

Employ *disincentives* for unsafe behaviors in a consistent manner:

- Enforce the safety procedures at all times;
- Consistently reprimand unsafe behaviors; and
- Do not punish employees without review, feedback, and/or retraining.

The next step in the research is to expand the data collection and develop the framework into a "thermometer" of safety culture. By automating the process via computer, companies could distribute this questionnaire to all their employees and quickly measure their safety culture. Just as a poor cholesterol test identifies increased risk of a heart attack, a poor safety culture test would indicate increased risk of an impending accident. More importantly, the safety culture test would help to identify aspects of corporate safety culture needing improvement.

Some limitations of this study are important to highlight. The primary limitation stems from the onerous data collection task. Given both the time and funding limitations of this study, data

from only three companies could be used. The range of safety records of these companies is smaller than desired, and all companies exhibited above average safety performance. An improved study would obtain data from a larger sample of companies and a wider range of safety performances. An examination of companies with lower than average safety records could yield more insights into the correlation between safety culture and safety performance.

A second limitation is that the questionnaire was distributed only in English. Although a reasonable sample from each company was achieved at the upper management, middle management, and field levels, non-English speaking employees did not complete the survey. In the future, a computer survey could be considered with multiple languages, leading to automation and expediency of the data collection process. Employees without access to computers would still require paper-based questionnaires.

Despite the stated limitations, this research shows that corporate safety culture is related to safety performance. The methodological framework presented in this paper provides a new set of tools for identifying and measuring corporate safety culture. The recommendations from this research are based on previously successful studies on construction safety. As more data are collected and new variables are observed, these results may be further refined; however, this paper serves as a fundamental advancement in the industry's understanding of corporate safety culture and its correlation to safety performance.

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