Empirical Analysis of Construction Safety Climate – A Study

S.V.S.RAJA PRASAD[1*] and K.P.REGHUNATH[2*]

Construction Industry Staff College, National Institute of Construction Management and Research, Hyderabad, India

Abstract

Safety in the construction industry has always been a major issue. Though much improvement in construction safety has been achieved, the industry still continues to lag behind most other industries with regard to safety. The safety climate of any organization consists of employee's attitudes towards and perceptions of, health and safety behavior. Construction workers attitudes towards safety are influenced by their perceptions of risk, management, safety rules and procedures. A measure of safety climate could be used to identify those areas of safety that need more attention and improvement. The dynamic nature of safety climate, which has the ability to change on daily basis, means there is a great need for reliable tools that can measure safety climate. Safety climate is a leading performance indicator that can provide insight into safety performance before accidents have occurred. In the present study a questionnaire was framed to ascertain safety climate in major construction organizations across India involved in construction of Thermal power plants, Hydro power plants, Highway projects, Bridge works, Refinery works, High rise works, Pipe line works and Dam woks and its content validity was verified. The internal consistency of the questionnaire was tested by using Cronbachs alpha coefficient. Data was collected based on questionnaire from employees working in various construction firms in India. The results of questionnaires survey was tested statistically by using the Kruskal – Wallis test to ascertain the attitudes of different categories of employees towards safety climate.

Key words: Safety climate, Management Commitment, Content validity ratio, Internal consistency, Subject-matter experts (SMEs)

1.0 Introduction

(Disclaimer: The mentioned study do not establish cause and effect relationship between the used variables. This paper makes an attempt to relate the variables. This paper does not include geographic, demographic and social profile of the respondents.)

Safety climate is a 'snapshot' of workforce perceptions about safety [Mearns et al., 1997][1]. The concept of safety climate emphasizes the importance of how organizations manage health and safety in the workplace. It is important that managers consider that any changes made to the operations of a business, will have an impact on workers perceptions. These perceptions have a psychological utility in serving as a frame of reference for guiding appropriate and adaptive task behaviour. As the workers environment changes around them, they adapt their perceptions and ultimately their behaviours. Measuring safety climate is still relatively new when compared with the concepts of social and work climate. Previous to Zohar's [2002][2] study of the Israeli manufacturing sector, the assessment of an organization's culture had never been specifically focused on assessing the attitudes of employees in relation to safety. Since then, there have been a number of studies and research teams that have aimed at developing a reliable measure of safety climate. As the concept has received more recognition and importance, there has been a growing increase in the number of safety climate measures; however, most of the focus has been on "refining question sets in order to improve face-validity. As the research field has grown, researchers have adopted a variety of methods in order to develop a quantitative measure of safety climate. Although a large amount of research has focused on what safety measures should be included in the make-up of a questionnaire, there is still confusion over the number and type of safety climate measures that should be included. Although there are similarities in the definitions of the two terms, safety culture is generally described as safety attitudes, values, and practices that exist at a deeper level than safety climate. Safety Culture refers to "individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and style and proficiency of, an organization's health and safety management. Safety Climate refers to the attitudes towards safety within an organization. Safety Climate refers more specifically to workers' perceptions of how safety is managed in the workplace and the likelihood those perceptions will contribute to a workplace accident.

2.0 Critical Factors of Safety Climate

The assessment of safety climate is facilitated by using well developed methods for assessing attitudes and work practices. In general terms, the attitude measures, or dimensions, fit into the following broad areas:

- Organizational Context;
- Social Environment;
- Individual Appreciation and
- Work Environment.

*2.*1 Organizational Context

- *Management Commitment* - Perceptions of management's Commitment towards health and safety issues.
- *Communication* - The nature and efficiency of health and safety Communications within the organization.
- *Priority of Safety* - The relative status of health and safety issues within the organization.
- *Safety Rules and Procedures* - Views on the efficacy and necessity of rules and procedures.

2.2 Social Environment

- *Supportive Environment* - The nature of the social environment at work, and the support derived from it.
- *Involvement* - The extent to which safety is a focus for everyone and all are involved

2.3 Individual Appreciation

- *Personal Priorities and Need for Safety* - The individual's view of their own health and safety management and need to feel safe.
- *Personal Appreciation of Risk* - How individuals view the risk associated with work.

2.4 Work Environment

- *Physical Work Environment* - Perceptions of the nature of the physical environment.

2.5 Organization Specific Factors

- Attitudes to specific safety related systems and procedures (for example, permit to work systems) may be included as necessary.

The relationships between the various system interfaces (that is, the target of the assessment process), the methods used, and the resulting measures (or climate indicators) can be plotted on a climate matrix. It should be noted that several complementary measures can be incorporated in each cell of the matrix, those shown in **Table 1** are only examples of what might appear there. The climate indicators shown in **Table 1** have been derived, for example 'Management Commitment' has been measured using a sub-set of items in the attitude questionnaire.

Table 1: Safety Climate Matrix

Systems Interface / **Methods**	**Organization/ Environment**	**Work Group/ Organization Systems**	**Individual/Group/ Organization Systems**
Attitude Questionnaires	Management Commitment, Work Environment	Supportive Environment, Involvement	Appreciation of Risk, Personal Priorities
Focus Group/ Interviews	Management Style	Co-operation	Shared values
Direct / Indirect Observation	Safety Systems Compliance	Safe Behaviours	Safe Behaviours

The critical factors are further subdivided and details are shown in **Table 2.**

Table 2: Safety Climate Factors

CRITICAL FACTOR	No. of Sub Elements
Organizational Context	
• Management Commitment	**10**
• *Communication*	**5**
• *Priority of Safety*	**4**
• *Safety Rules and Procedures*	**3**
Social Environment	
• *Supportive Environment*	**5**
• *Involvement*	**3**
Individual Appreciation	
• *Personal Priorities and Need for Safety*	**4**
• *Personal Appreciation of Risk*	**4**
Work Environment	
• *Physical Work Environment*	**5**
Total	**43**

3.0 Research Methodology

3.1. Validity and Reliability Testing for a Questionnaire

From an extensive literature review, a total of 43 success variables were identified. Before including them in the final draft of questionnaire, they were statistically validated using Content Validity Ratio (CVR). This internal validation was carried out by asking 52 experts (i.e. corporate safety heads, safety managers, safety engineers and senior safety officers who have been involved in managing safety in Construction projects for at least 10 years) whether or not the defined 43 variables were "1 = essential", "2 = useful but not essential" or "3 = not necessary". Degrees of necessity were used as success variables for safety program implementation. The data gathered were then calculated to obtain the CVR based on Lawshe's formula (Lawshe, 1975)[3].

3.1.1 Lawshe's Content Validity Ratio

In this approach, a panel of subject-matter experts (SMEs) is asked to indicate whether or not a measurement item in a set of other than a measurement item is "essential" to the operationalization of a theoretical construct. The SME input is then used to compute the CVR for each *i*th item in a measurement instrument (*CVRi*) as follows, where

$$\mathbf{CVR_i = [n_e – (N/2)] / (N/2)}$$

CVRi = CVR value for the *i*th measurement item, *ne* = number of SMEs indicating a measurement item is "essential," and *N* =Total number of SMEs in the panel. We can infer from the *CVR* equation +1.00, where a *CVR* = 0.00 means that 50% of the SMEs in the panel of size *N* believe that a measurement item is "essential." A *CVR* > 0.00 would, therefore, indicate that more than half of the SMEs believe that a particular measurement item is "essential," and, thereby, face valid. Lawshe (1975, p. 568)[3] has further established minimum *CVR*'s for different panel sizes based on a one-tailed test at the a = 0.05 significance the panel, then measurement items for a specific construct, whose *CVR* values are less than 0.37, would be deemed as not "essential" and would be deleted from subsequent consideration.

3.2. Cronbach's alpha coefficient (α)

In this study, a questionnaire's reliability was further verified by using Cronbach's alpha coefficient (α), which is a measurement of internal consistency. A single statement (item) was presented to employees and then this same statement was presented to the employees 3 weeks later. A test-retest reliability coefficient was calculated on this individual statement (item) since individual items can not have a Cronbach's alpha internal consistency reliability calculated. The statement presented to employees was, "Managements commitment towards health and safety." Employees were asked to respond to the statement using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). A multi-item scale was also developed and given to the same employees to measure

their attitude towards the management commitment. The multi-item scale is presented in **Table 3** to measure employee's attitude on "Managements commitment towards health and safety."

Table 3: Multi – item Scale for Management's Commitment

Item	Strongly disagree				Strongly agree
1. Management acts immediately when a safety Concern is raised.	1	2	3	4	5
2. Management acts only after occurrence of accidents.	1	2	3	4	5
3. Management reacts when informed about unsafe practices.	1	2	3	4	5
4. In my work place management works quickly to correct safety related issues.	1	2	3	4	5
5. In my work place manager shows interest in safety of employees.	1	2	3	4	5
6 In my work place managers/ supervisors motivate towards safety.	1	2	3	4	5
7. Managers/ supervisors express concern if safety procedures are not followed.	1	2	3	4	5
8. Management reacts on the suggestion given by the employees.	1	2	3	4	5
9. Managers/ supervisors explain about safe operating procedures to employees.	1	2	3	4	5
10. In my work place management give least importance to safety issues.	1	2	3	4	5

A description of the sections and related terms are as follows:

- ✓ Item means - These are summary statistics for the individual item means.
- ✓ Item Variances - These are summary statistics for the individual item variances.
- ✓ Inter-Item Correlations - This is descriptive information about the correlation of each item with the sum of all remaining items. In the example in **Table 3**, the correlation between the first item and the sum of the other items, the correlation between the second item and the sum of the other items, and so forth. The first number listed is the mean of these eight correlations (in our example .3824), the second number is the lowest of the eight (.0415), and so forth. Cronbach's alpha reliability coefficient normally ranges between 0 and 1. However, there is actually no lower limit to the coefficient. The closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale. Based upon the formula, ALPHA = rk / [1 + (k -1) r] where k is the number of items considered and r is the mean of the inter-item correlations. The size of alpha is determined by both the number of items in the scale and the mean inter-item correlations.
- ✓ Item-total Statistics - This is the section where one needs to direct primary attention. The items in this section are as follows:

  a. Scale Mean if Item Deleted- Excluding the individual item listed, all other Scale items are summed for all individuals and the mean of the summated items is given.

  b. Scale Variance if Item Deleted - Excluding the individual item listed, all other Scale items are summed for all individuals and the variance of the summated items is given.

  c. Corrected Item-Total Correlation - This is the correlation of the item designated with the summated score for all other items.

  d. Squared Multiple Correlation - This is the predicted Multiple Correlation Coefficient Squared obtained by regressing the identified individual item on all the remaining items.

e. Alpha if Item deleted - This is probably the most important column in the table. This represents the scale's Cronbach's alpha reliability coefficient for internal consistency if the individual item is removed from the scale.

3.3 Questionnaire Survey

A questionnaire survey was designed by incorporating the applicable 43 variables and the questions asking respondents to rate the level of influence of each variable. It aimed at obtaining the importance of each factor in ascertaining safety climate as perceived by the respondents. To extract the degree of influence, the respondents were asked to rate each factor on the five-point Likert scale, varying from "not important" (1) to "extremely important" (5). In addition, the respondents were asked to evaluate the actual status of each factor based on the amount of care currently given to it. The survey was carried out on large-scale construction projects in India, across eight states. Each organization is employing more than 800 workers. Several manners were used to distribute the questionnaires to the respondents. Nevertheless, to motivate the respondents to participate in the survey, face-to-face or direct delivery was preferred.

3.3.1 Characteristics of Respondents

The respondents are classified into three groups, namely project engineers, supervisors and workers. The responses from these three groups are shown in **Table 4**, which shows a total of 106 responses. The responses from three different groups are tested statistically by using the Kruskal-Wallis Test.

Table 4: Response Details

Socio economic factors	**Project Engineers**	**Supervisors**	**Workers**	**Overall**	**Percentage**
Less than 10	14	9	8	31	29
Between 10-15	9	19	11	39	37
Between 16-20	10	8	4	22	21
More than 20	7	2	5	14	13
Responded	40	38	28	106	100
Selected for survey	71	59	70	200	--
Percentage responded	38	36	26	100	--

3.3.2 Kruskal- Wallis H –Test

The Kruskal Wallis test, also known as H - test is used to test the null hypothesis that several independent samples drawn from the same population or identical populations. All observations of all samples are pooled together and recorded in ascending order. The observations are ranked from low to high, so that lowest value will get a rank of 1 and so on. Based upon these ranks, the relative ranks are assigned to each observation in each sample. The sum of ranks in each sample is taken and the value of this sum is recorded.

The null hypothesis is that the attitude towards safety climate of three different groups is same. To extract the degree of influence, the respondents were asked to rate each factor on the five-point Likert scale, varying from "not important" (1) to "extremely important" (5) and the total scores for 43 variables from different categories of employees are tabulated (refer to **Appendix - 1**). The Kruskal Wallis H – test is applied for the scores obtained. The value of H is calculated by using the formula,

$$H = 12 / N (N+1) \sum_{i=1}^{3} \{R_i^2/n_i\} - 3 (N + 1)$$

Where $N = n_1 + n_2 + n_3 = 106$,

R_1, R_2, R_3 are the sum of ranks of engineers, supervisors and workers.

4.0 Results and Discussions

4.1 Content validity ratio

According to Lawshe, with a panel of 52 respondents, the minimum value of CVR needs to be at least 0.37 in order for it to be acceptable. As a result, variables which have CVR values less than 0.37 were not included in final questionnaire. This preliminary study showed that all 43variables had CVR value greater than 0.37, varying from 0.80 – 0.95. Thus, it was inferred that all 43 variables were strongly valid for this research and they could be included in the final form of a questionnaire.

4.2 Internal Consistency

To know the internal consistency of the items of the questionnaire, reliability test was conducted on a small group of respondents who were requested to complete a final questionnaire. A total of 40 respondents were involved in the reliability test. To obtain α, the Statistical Package for Social Sciences (SPSS) software program was used to analyze raw data. The results of these analyses implied that the actual data collection could be performed by using this questionnaire. **Table 5** shows the item-analysis output from SPSS for the multi-item scale of employee's attitude towards "Management's commitment" towards health and safety.

Table 5: Item Analysis Output

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	3.6809	3.3205	3.9812	0 .7002	1.2100	0.0730
Item Variances	1.0801	0.7017	1.4110	0 .7100	2.0110	0.0709
Inter-Item Correlations	0.3789	0.0415	0.6011	0.5450	14.1301	0.02001

Item Total Statistics	Scale Mean If Item Deleted	Scale Variance If Item Deleted	Corrected Item Total Correlation	Squared Multiple Correlation	Alpha If Item Deleted
Item 2	25.1300	25.0501	0.6051	0.4899	0.8010
Item 4	25.8001	23.3010	0.5351	0.3700	0.8123
Item 5	25.7222	24.6425	0.4301	0.4454	0.8200
Item 6	25.2500	25.2139	0.5134	0.4601	0.8141
Item 7	25.6250	22.9200	0.6600	0.5105	0.7904
Item 8	25.7143	24.3343	0.4443	0.3119	0.8278
Item 9	25.1250	24.0001	0.6124	0.5222	0.8003
Item 10	25.4445	24.1311	0.6332	0.4841	0.8021

Reliability Coefficients for Item	Alpha
	0.8124

The value of the alpha coefficient for the data obtained from the respondents was 0.798 demonstrating acceptable reliability of the questionnaire. George and Mallery (2003) provide the following rules of thumb: "_ > .9 – Excellent, _ > .8 – Good, _ > .7 – Acceptable, _ > .6 – Questionable, _ > .5 – Poor, and _ < .5 – Unacceptable" (p. 231). While increasing the value of alpha is partially dependent upon the number of items in the scale, it should be noted that this has diminishing returns. It should also be noted that an alpha of 0.798 is reasonably good.

4.3 Level of safety climate

The sum of ranks R_1 (engineers), R_2 (supervisors) and R_3 (workers) is shown in **Table 6**.

Table 6: Sum of Ranks

S.No	Sum of ranks of Engineers	Sum of ranks of Supervisors	Sum of ranks of Workers
1.	1869	2060.5	1741.5

The calculated value of H is 4.204. Since the distribution of H statistic is approximated by Chi square distribution. Comparing the computed value of H with the critical value of Chi square at 0.05 level of significance and at degrees of freedom 2, the critical value as 5.991. Since the computed value of H is less than the critical value of Chi square, the null hypothesis is accepted, which states that there is significant difference in the level of safety climate among three groups under consideration.

5.0 Conclusions

This study has established how complex the overall relationship of safety climate among three different groups. This degree of complexity requires that much more research is undertaken on the relationship between actual safety performance and safety climate. Although a large amount of research has focused on what safety measures should be included in the make-up of a questionnaire, there is still confusion over the number and type of safety climate measures that should be included. A Questionnaire with no content validity will not operationalize a theoretical construct of interest, and quantifying the content validity of questionnaire is used in the research. The significant difference in the level of safety climate among three groups under consideration is mainly due to organizational Context consists of Management Commitment, Communication, Priority of Safety and Safety Rules and Procedures. The supervisors who act as bridge between management and workers are strongly of the opinion that management commitment is crucial variable to improve safety climate in construction industry. The role of government to enforce regulatory requirements is also affecting safety climate and some state governments are not implementing the requirements particularly for construction industry. Firstly, Safety training to all employees, involving all categories of employees in decision making relating to safety issues and secondly, managers can encourage supervisors to be more involved in safety activities. Suggested behaviors for supervisors include being receptive about workforce ideas about ways to improve health and safety, will definitely improve safety climate in construction industry.

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Appendix – 1

S.No	Engineers	Supervisors	Workers
1	189	178	188
2	178	192	179
3	180	169	190
4	190	178	191
5	169	189	199
6	181	190	189
7	189	165	182
8	190	178	185
9	195	187	175
10	196	190	196
11	188	198	177
12	188	177	200
13	186	178	201
14	190	188	199
15	191	185	193
16	191	198	177
17	187	197	178
18	199	179	192
19	198	180	193
20	197	180	193
21	196	193	184
22	190	195	183
23	171	196	189
24	181	169	190
25	161	166	191
26	178	174	179
27	160	188	191
28	169	195	197
29	171	192	-
30	180	193	-
31	165	194	-
32	167	168	-
33	175	190	-
34	189	199	-
35	190	200	-
36	199	201	-
37	168	166	-
38	173	190	-
39	179	-	-
40	183	-	-

Appendix – 1: Showing the respondents scores