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An Empirical Analysis On Evaluation of Safety Attitudes And Perceptions of Civil Engineering And Construction Management Personnel

V. Thirugnana Sambandan*[1, a], T. Felix Kala[2, b], S. Nallusamy[3, c]

[1]*Research Scholar, [2]Professor & Dean, Department of Civil Engineering, [3]Professor & Dean, Department of Mechanical Engineering,
Dr. M.G.R. Educational and Research Institute, Chennai - 600 095, Tamil Nadu, India

[a] vtsambandan@gmail.com, [b] felixkala.civil@drmgrdu.ac.in, [c] ksnallu@gmail.com

Abstract: *Safety climate is defined as the attitudes and perceptions of the personnel about their work settings. The term safety climate is derived from the organisational climate. Literatures reveal that the climate is the manifestation of the culture. The safety culture is an integral part of an organisational culture. The organisational culture varies from organisation to organisation and hence the safety culture also varies from organisation to organisation. The safety culture is influenced by the attitudes and perceptions of the personnel working in the particular organisation. The safety culture can be measured by the safety climate. In other words, the attitudes and perceptions related safety will have to be captured to ascertain the safety culture prevailing in the organisations. The primary objective of this study is to ascertain the differences and to identify the most discriminating safety climate variables among various group organisations. The attitudes and perceptions of construction personnel were measured through questionnaire based survey. Principal Component Analysis (PCA) was performed for the extraction of safety climate factors. The factor analysis extracted four factors for the safety climate. Out of 25 variables 24 variables were retained in the final factor solution. The descriptive analysis revealed that the safety awareness and beliefs among the management personnel are relatively high, management commitment towards safety is moderate and the supportive work environment needs improvements to enhance the safety culture. Further, a linear discriminant analysis was also performed to determine the most discriminating safety climate variables between the three group organisations. Out of 21 variables 12 variables were revealed significant differences amongst three groups. All six variables of physical work environment factor revealed statistically significant differences among the group means.*

Keywords: *Construction, Safety Culture, Organisational Culture, Questionnaire, PCA, Linear Discriminant Analysis, SPSS*

I. INTRODUCTION

Culture is an integral part of human lives. No society can exist without culture and hence it is learned and shared. Culture is always a group phenomenon and shared within the organisations. It is learned and derived from his social environment. Culture is set of vision, ethical values, norms, structures, symbols, language, presumptions, underlying beliefs, and practices [1-3]. For the current study, review of following two concepts is essential for the deeper understanding.

1. Organisational culture / climate
2. Safety culture / climate

A. Organisational culture

Organizational culture is defined as “the way things are done across the organisation”. According to Schein culture is the concept of sharing and it has the four structural elements such as: stability, depth, breath and pattern [4, 5]. The four intrinsic characteristics of culture can be explained as below.

1. Not only shared but also stable
2. Deeply embedded and hence less visible
3. Pervasive across the organisation
4. Patterning or Integration of the elements

It is a set of shared presumptions which guides the organisations and also it defines appropriate behaviour for the people or group for various circumstances. Organizational culture influences the way people and groups work together and communicate with each other [6, 7].

B. Safety culture

The literatures reveal that the terms climate and culture were used interchangeably and definitions of both terms were sharing the common border in the social science researches. Organisational culture is the synonym for the organisational climate in contemporary literatures. In this context, construction safety culture and construction safety

climate researches were echoing the same concept. Further, the following literatures reveal the fact that the term safety culture is derived from the term organisational culture. It is argued by Reason that the definition for organisational culture given by Uttal holds good for safety culture also [8-10]. In this order, it can be construed that the safety culture is the:

- Special kind of an organizational culture [11]
- Subset of organizational culture [12]
- Form of organizational culture [13]
- Sub-feature of organisational culture [14]

Having seen the etymologies and the nexus between organisational culture and safety culture, the following section reviews the definition of safety climate. The literatures reveal that the safety climate can be defined as below

- Point of views of people regarding a particular entity [15]
- Molar perceptions people about work environment [16]
- Expression of cultural presumptions at work place [17]
- Indicator of safety culture [18]
- Tangible manifestation of safety culture [19]
- Temporal expression of culture [20]
- Expression of strategic safety management [21]

Having seen the etymologies and the nexus between safety culture and safety climate, the following section review the nexus between the safety culture and safety performance

C. Effect of Safety climate on safety performance

Safety climate is positively and significantly associated with safe work behaviour. According to Martin the organisational cultures can not only be integrated but also be differentiated. The primary reason for the existence of differentiated or fragmented culture is due to the presence of multiple subcultures [22, 23]. This is applicable for the safety culture also as the same being the integral part of organisational culture.

In this order, the safety climate study carried out by Silvia et al and concluded that the safety climate revealed the positive and significant relationship with other aspects of safety performance [24]. Further, it is reported that the safety climate may vary from site to site due to the prevalence of safety sub-cultures. An another safety climate study conducted by Prasad and Rao concluded that many of the safety climate variables of four safety climate factors revealed statistically significant differences among three different construction sectors in India.

As the safety culture is significantly influenced by the organisational culture, the above findings are important for the current study to determine the most discriminating safety climate variables among different organisations.

II. RESEARCH METHODOLOGY

It can be seen from the literatures that Zohar was the first researcher who coined the term safety climate which manifest the attitudes and perceptions of the employees with regard to their work environment. He has used questionnaire survey as research tool for his investigation. Also, Toole reiterated that the questionnaire is the most valuable research tool for attitude and perception survey. If the researcher knows what exactly he wants to measure, then the questionnaire survey is the appropriate tool for gathering data if the scholars precisely aware that what is being measured. In order to accomplish the goal, a questionnaire surveys was established. The targeted respondents were competent civil engineering and skilled civil supervisory personnel in construction sector. The questionnaire deployed in earlier studies in Pakistan and India were improved suitably in the current context of construction sector [25-29]. The construct was related to safety climate (attitudes and perception) with 25 variables.

The targeted respondents for this survey were briefed before starting the survey with its purpose and necessary assurance was given that the due ethical care will be in place to protect anonymity of the respondent. The respondents were informed to enter his level of acceptance to the each variable in the questionnaire in 5 point Likert scale. Prior to subjecting these into principal component analysis, a T-test for equality of means was carried out. The t-test results shown that there were no statistically significant differences in ideas between two management personnel such as qualified engineers and experienced supervisors

III. RESULTS AND DISCUSSIONS

A. Exploratory Factor Analysis

All requisite basic analysis like data screening, suitability checks were performed prior to principal component analysis. The data collected in both surveys were loaded into SPSS software which has principal component analysis as a default extraction method and Varimax as the default rotation method. The summary of test results are presented in Table 1

Table 1: Summary of Principal Component Analysis

Description of Measures	Safety Climate
Variables considered for EFA	25
Sample size (N)	130
Subjects To Variable (STV) Ratio	5.20
KMO (Keiser Meyer- Olkin) Statistic	0.849
Bartlett's test of Sphericity - Chi-Square	2327.596
Degree of Freedom (d_f)	210
P value	0.000
Factors obtained	4
Variables retained after EFA	21
Total percentage variance explained (%)	73.79
Minimum STV Ratio 5:1 [30] Total % variance explained must be greater than 60% [31] KMO values ranging from 0.80 to 0.89 is meritorious [32]	

The Cronbach's alpha reliability coefficient, the most important and pervasive statistic were ranging 0.879 to 0.894 from for safety management construct and 0.804 to 0.391 for national culture construct. According the coefficient alpha ranging from 0.84 to 0.90 is reliable, 091 to 0.93 are strong and 0.93 to 0.94 is excellent [34].

The variables having factor loadings less than 0.50 and measure of sampling adequacy less than 0.50 were dropped from the final factor solution. The combination of Kaiser Criterion and Scree plot is used for the extraction of factors for safety climate construct. The eigenvalues were ranging from 2.930 to 4.708 for the safety climate factors [35-37]. The scree plot with eigenvalues for the attitudes and perceptions of management personnel working at construction site is presented Figure 1.

The principal component analysis extracted four factors. The first three factors were labelled based on the previous studies [38]. The fourth factor was labelled as safety commitment as the variables in the factor are predominantly related to the management commitment towards safety, The variables such as safety communication, safety inspection, skill specific safety training and creating risk awareness are the primary responsibility of the management to foster and sustain good safety culture. The total variance extracted for the overall safety climate construct with four factors is 73.79 %. The results of PCA along with factor wise eigenvalues, percentage variance extracted for individual factors and the reliability coefficients are presented in Table 2.

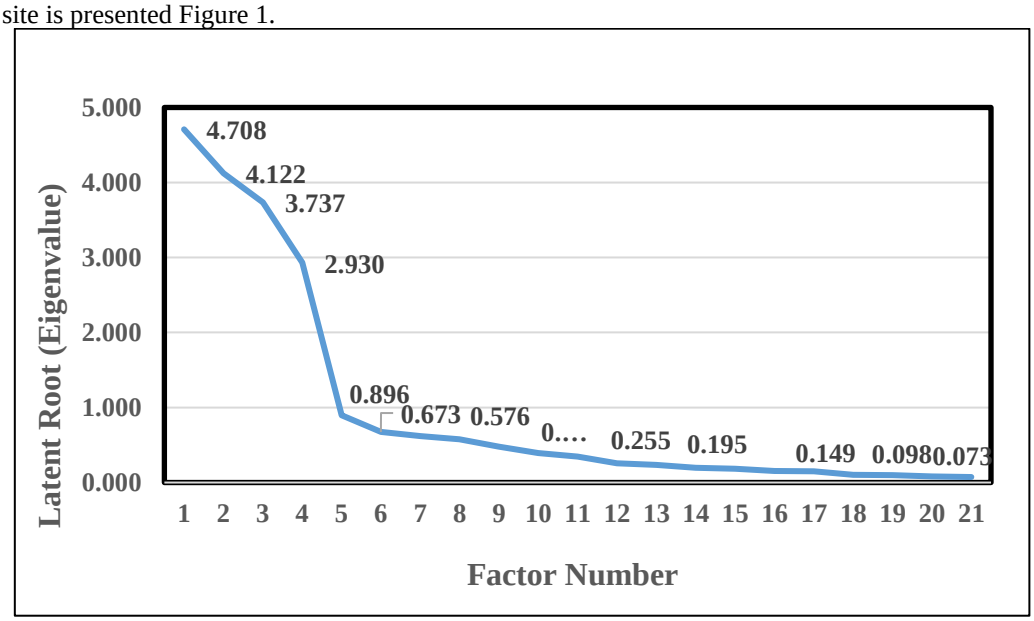

Fig.1: Eigen Value Plot for Scree Test Criterion

Table 2: Results of PCA- Construction Safety Climate

Description of Factors		Description of variables	Loadings
Factor :1 Awareness & Belief		V1-Safety Priority	0.842
Variance (%)	22.42	V2- Management safety action	0.866
Eigen value	4.708	V3- Personal Protective Devices	0.901
Cronbach's Alpha	0.940	V4- Safety Procedures awareness	0.879
		V5- Construction site hazards	0.841
		V6- Hazard identification	0.811
Factor :2 Physical Environment		V20-Anxiety at worksite	0.678
Variance (%)	19.63	V21- Shortcuts to bypass safety	0.738
Eigen value	4.122	V22- Risk propensity	0.795
Cronbach's Alpha	0.914	V23- Availability of right equipment	0.871
		V24- Escalation of Safety Concerns	0.849
		V25 Resolving basic safety issues	0.828
Factor :3 Supportive Environment		V8-Safety training	0.848
Variance (%)	17.79	V9-Good Working relationship	0.908
Eigenvalue	3.737	V10-Accident Prevention	0.904
Cronbach's Alpha	0.904	V11- Safe work habits	0.704
		V14 -Safety feedback	0.620
Factor :4 Safety Commitment		V15- Safety communication	0.544
Variance (%)	13.95	V16- Safety inspections	0.799
Eigen value	2.930	V17- Skill specific safety training	0.863
Cronbach's Alpha	0.902	V18- Occupational risk awareness	0.842

B. Linear Discriminant Analysis.

The primary objective of this study is to ascertain the differences and to identify the most discriminating variables within the factors among three groups. Hence, the linear discriminant analysis is carried out. The individual group differences and overall differences are assessed. Wilks' lamdba also known as U- statistic is a very extensively used test statistic, in many multivariate analyses including linear discriminant analysis. Wilks' lamdba is equivalent to the proportion of total variability in the Z scores defined by discriminant function not explained by variations amongst the groups. It measures how well each function differentiates cases into groups. In other words, it tests how well each predictor or the independent variable (IV) adds values to the model [39, 40].

Wilks' lamdba is helpful to determine the presence of statistically significant differences among the group means on a set of dependent variables. In general, the groups are represented by categorical variables in the dataset. Wilks' lamdba can also be converted into F ratio in order to arrive at the significance level. The values are ranging from 0 to 1, where zero means complete discrimination, and one means zero discrimination [41]. The discriminatory ability of the function will be greater if the wilks' lambda values are smaller. The results of discriminatory analysis with wilks' lambda, F ratio and significance values are presented below in Table 3 for further interpretation.

Table 3: Results of Three Group Discriminant Analysis

S.No	Independent Variable Number	Group Means of Dependent Variables			Test of Equality of Group Means			Between Groups
		Group :1 (N=43)	Group :2 (N=43)	Group :3 (N=44)	Wilks Lambda	F-Value	Significance	
Factor :1 Awareness & Beliefs								
1	V1	4.333	3.977	4.118	0.963	2.439	0.091	1 and 2
2	V2	4.256	4.057	4.118	0.962	2.516	0.085	1 and 2
3	V3	4.186	3.953	4.026	0.961	2.573	0.080	1 and 3
4	V4	4.333	3.953	4.029	0.983	1.092	0.339	1 and 3
5	V5	4.186	4.000	3.882	**0.932**	4.618	0.012	1 and 3
6	V6	4.163	3.930	3.882	**0.939**	4.131	0.018	1 and 3
Factor :2 Physical Work Environment								
7	V20	3.302	2.558	2.824	**0.874**	9.159	0.000	1 and 3
8	V21	3.419	2.721	3.000	**0.879**	8.751	0.000	1 and 2
9	V22	3.395	2.465	2.618	**0.758**	20.241	0.000	1 and 2
10	V23	3.302	2.535	2.647	**0.831**	12.906	0.000	1 and 3
11	V24	3.372	2.372	2.500	**0.735**	22.940	0.000	1 and 3
12	V25	3.163	1.977	2.265	**0.697**	27.648	0.000	1 and 3
Factor :3 Supportive Work Environment								
13	V8	3.837	3.628	3.824	0.986	0.913	0.404	1 and 3
14	V9	3.977	3.698	3.794	0.969	2.044	0.134	1 and 2
15	V10	3.907	3.791	3.765	0.990	0.664	0.517	1 and 2
16	V11	3.930	3.744	3.705	0.979	0.845	0.437	1 and 3
17	V14	3.977	3.628	3.647	**0.907**	6.536	0.002	1 and 2
Factor :4 Safety Commitment								
18	V15	3.884	3.535	3.588	**0.928**	4.931	0.009	1 and 2
19	V16	3.953	3.442	3.618	**0.928**	4.958	0.008	1 and 2
20	V17	3.814	3.395	3.529	0.955	2.998	0.053	1 and 2
21	V18	3.721	3.465	3.441	0.966	2.267	0.108	1 and 2

Wilks Lambda (U Statistic) and Univariate F-Ratio with 2 and 157 degrees of freedom

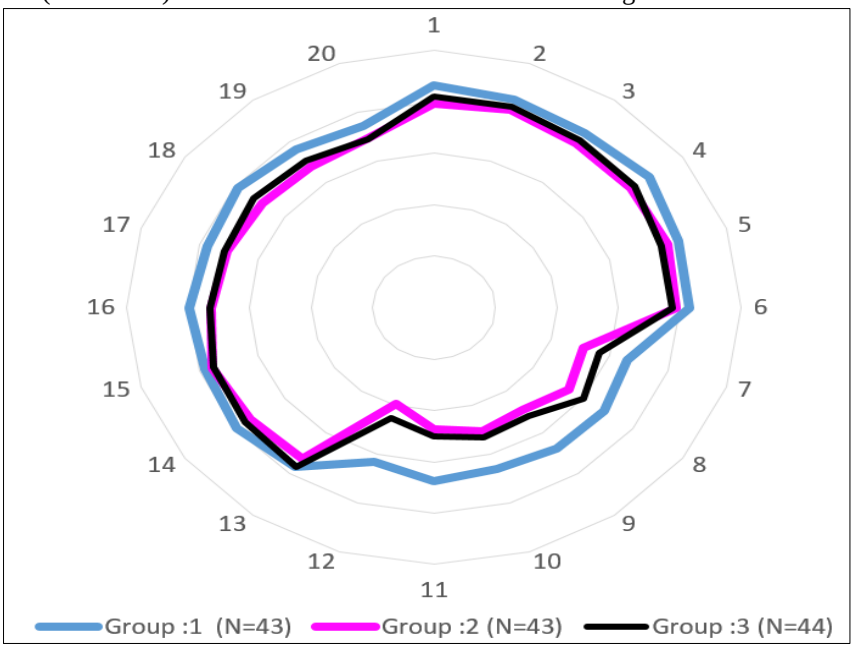

Fig. 2: Radar Chart Showing Variable Wise Group Means for Three Groups

The review of salient measures of discrimination such as wilks' lambda, F ratio (simplified ANOVA) and significance measures is revealed the following.

- On a univariate basis, 12 out of 21 variables revealed statistically significant differences amongst the group means. The twelve variables with statistically significant differences in the safety climate construct include V5, V6, V20, V21, V22, V23, V24, V25, V8, V9, V10, V14, V15, V16, V17 and V18
- The most significant variables within the specific factor had lowest wilks' lambda. A larger significance for the variable is relate to higher overall discrimination
- A visual inspection reveals that all the six variables present in the physical work environment factor were significant. (V20, V21, V22, V23 V24 and V25). The variables V21 and V22 differ significantly between the groups 1 and 2. The other four variables V20, V23 V24 and V25 differ significantly between the groups 1 and 3
- Only one variable V14 (Safety feedback) out of five variables in supportive environment factor provides statistically significant differences. This variable differs significantly between the groups 1 and 2
- Two variables V5 and V6 (Site hazards & Hazard identification) out of four variables in awareness and belief factor provide statistically significant differences. Both variables differ significantly between the groups 1 and 3
- Two variables V15 and V16 (Safety communication & Safety Inspection) out of four variables in safety commitment factor provide statistically significant differences. Both variables differ significantly between the groups 1 and 2.

IV. CONCLUSION

This study was carried out to investigate the prevailing safety climate and to ascertain the differences among the safety climates of various organisations. The primary objective was to identify the most discriminating safety climate variables among various group organisations.

- The descriptive analysis for the attitudes and perceptions of construction personnel revealed that the safety awareness and beliefs among the management personnel are relatively high, management commitment towards safety is moderate and the physical work environment for the groups 2 and 3 needs improvements to enhance the safety culture.
- The factor analysis revealed the fourth factor management commitment towards safety for the current study. This is an important factor for the safety culture to sustain and nurture the safety culture.
- Further, the linear discriminant analysis revealed that out of 21 variables, 12 variables revealed significant differences amongst three groups. All six variables of physical work environment factor revealed statistically significant differences among the group means.
- It can be concluded the existence of difference in safety climate among various organisation to the presence of multiple subcultures in safety culture and organisational culture. Hence, organisations need to conduct safety climate survey in their construction sites to understand the attitudes and perceptions of the personnel.
- The periodical safety climate surveys will be of great help for the organisations to enhance strong safety climate factor and focus on weak safety climate factor so that the untoward incidents can be prevented through management commitment and employee involvement towards safety.

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