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Factor Analysis on Safety Management in Construction Projects

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ABSTRACT - ***This research paper is intended to provide the respondents with necessary information needed to better manage the safety management in construction projects. The main objective of the paper was to find out the crtical factors through questionnaire survey. This study was conducted in a detailed manner through questionnaire survey and collecting the responses from various construction projects. The factor analysis was utilized using SPSSv.21 software*** **and factors were extracted and interpreted*.*** ***The result showed that the most influential factor is management support and workers responsibility. The results of the study revealed that there are fifteen major factors creating safety problems in the construction industry.***

Keywords - *Factor analysis, Safety, SPSS, Questionnaire*

1. INTRODUCTION

The construction industry continues to play a major role in the development of our country. However, the construction industry has faced a wide range of challenges, one of which is the frequent occurrences of accidents at the workplace. Safety programs are now a key to eliminating work-related accidents and injuries. The concept of construction site safety has been widely accepted as a crucial issue in the construction industry of India in recent years. The general aim of the research is to find ways for further improving construction site safety at the construction projects. Therefore, it is worthwhile to conduct a research on investigating the key factors influencing the success of safety management in construction industry.

Zohar (1980) developed the first measure, based on an Israeli sample in 1980 using a 40-item questionnaire covering metal fabrication, chemical, textile and food processing industries. After factor analysis, his final model included 8 dimensions with workers' perceptions of the importance of safety training, management attitude towards safety, effects of safe conduct on promotion, level of risk at workplace, effects of work place on safety, status of safety officer, effects of safe conduct on social status and status of safety committee.

Langford, Rowlinson and Sawacha (2000) studied the safety behaviour and safety management in the UK construction industry. The study was conducted through questionnaire survey with 126 directly employed construction workers in 10 companies. Some 56 variables were identified as having a potential influence upon attitudes to safety. The initial data analysis found that 12 technical factors significantly correlated to the development of strong positive attitudes towards safety management. Second-order analysis, using factor analysis, isolated five variables that had a major influence on safety attitudes. The five factors were: organizing for safety, supervision and equipment management, industry norms and culture, attitudes to risk taking and management behaviour.

Tam, Zeng and Deng (2003) studied the elements of poor construction safety management in China. This paper aims to examine the status of safety management in the Chinese construction industry, explore the risk-prone activities on construction sites, and identify factors affecting construction site safety. The study reveals that the behaviour of contractors on safety management is of grave concern, including the lack of provision of personal protection equipment, regular safety meetings, and safety training. The main factors affecting safety performance include poor safety awareness of top management, lack of training, poor safety awareness of project managers, reluctance to input resources to safety and reckless operations.

Aksorn and Hadikusumo (2007) conducted a safety program performance in Thai construction projects. The study was conducted through questionnaire survey with 80 respondents from medium and large-scale construction projects. The survey intended to assess and prioritize the degree of influence of those success factors on the safety programs as perceived by the respondents. The authors concluded that the most influential factor is management support. Furthermore, using factor analysis, the 16 critical success factors could be grouped into four dimensions: worker involvement, safety prevention and control system, safety arrangement, and management commitment.

Choudhry, Fang and Syed (2008) described an exploratory study of site safety management in construction sites at Hong Kong. The study was conducted through questionnaire survey to determine the status of safety at the construction sites. All employees of the company and its subcontractors participated in the survey from 20 construction projects. In total, 1,022 valid records were obtained from the construction sites. The analysis provided useful information on eight aspects of construction safety, including safety policy and standards, safety organization, safety training, inspecting hazardous conditions, personal protection program, plant and equipment, safety promotion, and management behaviour. The findings of the survey provide practical knowledge to construction project managers and construction safety practitioners in order to make their sites safer.

Choudhry, Fang and Lingard (2009) conducted a study on measuring safety climate of construction projects in Hong Kong. 71 questionnaires were analyzed using Health and Safety climate survey tool. Seven additional items were included to make the questionnaire suitable for the safety managers in Hong Kong. The questionnaire was examined for content validity, structure validity and offensiveness of the language. The questionnaire was presented in English and Chinese and consisted of 42 states about safety issues. Factor analysis was used to identify the underlying cluster of factors which affected the safety climate. This technique revealed two dimensions: management commitment and employee involvement and inappropriate safety procedure and work practices.

Cheng, Ryan and Kelly (2011) studied the influence of safety management practices on project performance in the construction industry. In the study, the levels of 15 popular safety management practices (SMP) and five project performance criteria were rated by 232 respondents. An exploratory factor analysis was conducted, and three safety management practice categories–information, process, and committees–were extracted. Of these three categories, safety management process was perceived by the construction practitioners as being the most important, followed by safety management information and committees. Moreover, the effect of three SMP categories on a composite project performance variable was tested using hierarchical regression analysis. Results indicate that the ‘‘information’’ and ‘‘committees’’ categories were associated with project performance positively and significantly. One of the major conclusions of the study was that the construction industry has paid relatively less attention to safety management committees, which were empirically analyzed as having a strong perceived impact on project performance. In order to improve project performance, construction companies should promote the criticality of safety management committees.

Hassanein and Hanna (2008) studied Safety Performance in the Egyptian Construction Industry. This study presents the results of a questionnaire survey that was conducted among a selected sample of large-size contractors operating in Egypt, as well as a comparison of the safety approaches in both the United States and Egypt. The results revealed that safety programs applied by large-size contractors in Egypt were less formal than those applied by their American counterparts. Only a few companies had accident records broken down by projects and provided workers with formal safety orientation. Finally, the author recommended that reforms in the way of the employer’s contribution to social insurance were necessary; thereby linking accident insurance costs to the contractor’s safety performance. This was meant to serve as a strong incentive for safety management.

Zubair, Kanya Lal and Allah Bux (2013) carried out a study to identify the critical factors affecting the safety program performance in Pakistan construction industry. A questionnaire survey was conducted to highlight the influence of the Construction Safety Factors. The questionnaire survey was analyzed using AIM (Average Index Method) and rank correlation test was conducted between different groups of respondents to measure the association between different groups of respondent. The finding was that management support is the critical factor for implementing safety program on projects. From statistical test, the author further concluded that all respondent groups were strongly in favour of management support factor as CSF (Critical Success Factor).

2. MATERIALS AND METHODS

Questionnaire survey was conducted among construction professionals to identify their opinion towards safety management in construction industry. Survey through questionnaires was found effective because of the relative case of obtaining standard data appropriate for achieving the objectives of this study. Based on the literature cited, various factors were selected. The study was conducted by developing a questionnaire and collecting the responses from construction firms. For the survey questionnaires was framed to identify the critical factors. The methodology of the study is as presented in Figure.1.

Figure1: Methodology of the Study

The questionnaire was prepared and sent to three main individuals responsible for the project (Contractor, Client and Consultant) and the effect of each factor has been evaluated by adopting a five-point likert scale of 1 to 5 (1 = Strongly Agree; 2 = Agree; 3 = Neutral; 4 = Disagree; and 5 = Strongly Disagree;). Among 500 questionnaires sent to construction professionals for investigation, 406 questionnaires were completed and returned by respondents, after eliminating incomplete responses of the questionnaires, only 343 full responses were found to be properly completed and useful for analysis. Details of grouping aspects and related factors are given in Figure 2.

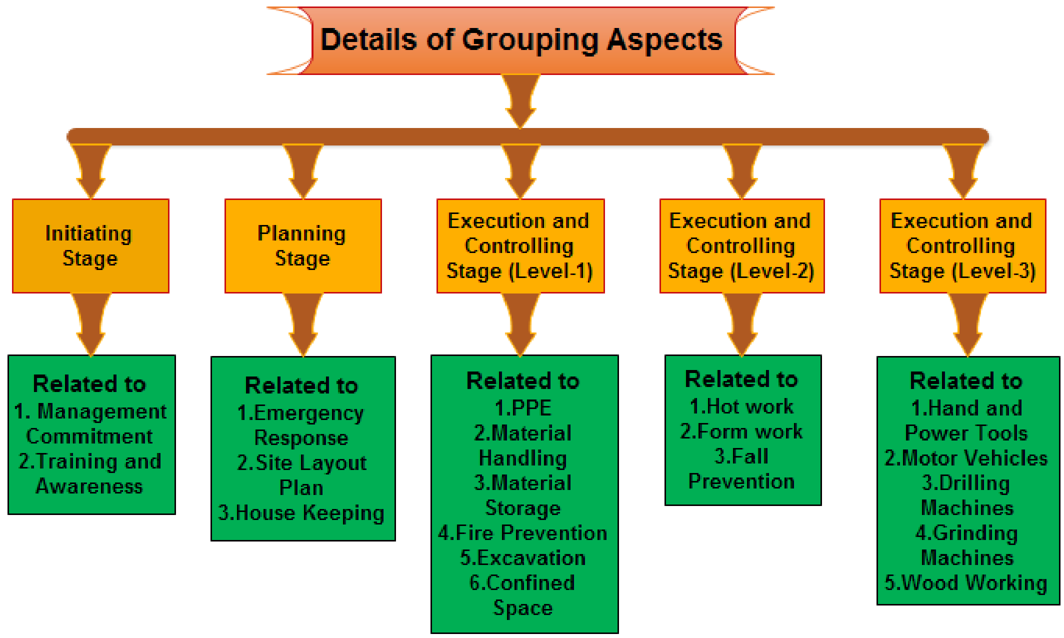

Figure 2: Details of Grouping Aspects and Related Factors

3. METHOD OF ANALYSIS

The questionnaire survey was conducted to determine the importance of critical success factors for safety management which was perceived by contractors, clients and consultants working within Construction Industry. In this paper, factor analysis was used to identify the critical success factor for safety management in construction industry. The Statistical Package for Social Science (SPSS v.21) was utilized to conduct factor analysis. Prior to performing a factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett‘s test of Sphericity were used to determine the suitability of the data for factor analysis. Factor analysis was carried out on 78 safety factors in construction industry.

4. RESULTS AND DISCUSSION

Table 1 shows the results of descriptive statistic and communalities in the safety factors on construction industry. The rank was provided according to the higher mean value, if both factors mean values are equal then we considered the lesser standard deviation value is taken as higher rank. From the descriptive analysis conducted, the mean value was in the range of 2.64 to 3.21. Average communality of the variables after extraction was above 0.40.

Table 1: Results of Descriptive Statistics and Communalities

Si.No	Factor No.	Aspects and Factors	Descriptive Statistics			Communalities	
			Mean	S.D	Rank	Initial	Extraction
		Initiating Stage					
1	IS2	Everyone aware of the contents of the safety policy?	3.06	0.687	26	1.000	.855
2	IS3	Safety plans and safety procedures?	3.07	0.685	25	1.000	.870
3	IS6	Safety committee?	3.10	0.678	17	1.000	.885
4	IS7	Employees given safety orientation?	3.12	0.663	8	1.000	.860
5	IS8	Employees given specialized training where needed?	3.13	0.667	6	1.000	.809
6	IS10	Safety material displayed on the site?	3.11	0.668	12	1.000	.860
		Planning Stage					
7	PS15	Qualified doctor/nurse available on site?	2.79	0.679	66	1.000	.818
8	PS16	Any arrangement with hospital for emergency treatment?	3.13	0.687	7	1.000	.790
9	PS17	Team trained in emergency response procedures?	2.88	0.721	52	1.000	.792
10	PS18	Workers aware of the emergency procedures?	2.93	0.71	44	1.000	.817
11	PS19	Emergency telephone numbers displayed?	3.11	0.673	13	1.000	.853

12	PS27	Scrap dump areas?	2.86	0.698	53	1.000	.963
13	PS28	Special storage areas for petrol, flammable materials, explosives etc…?	2.88	0.705	51	1.000	.963
14	PS29	Access roads suitable for the movement of plant and vehicles?	2.84	0.688	56	1.000	.952
15	PS30	Ambulance room/ emergency vehicle suitable located?	3.15	0.706	2	1.000	.904
16	PS31	Site kept neat and tidy?	2.79	0.706	65	1.000	.800
17	PS34	Materials and equipments stored properly?	3.06	0.708	27	1.000	.591
18	PS35	Local scrap yard provided?	2.76	0.718	73	1.000	.835
19	PS39	An easy access to Electrical control panels, Fire extinguishers, First Aid boxes etc…?	2.74	0.723	75	1.000	.648
Execution and Controlling Stage (Level-1)							
20	(EC1)42	Workers wearing full body safety harness while working at heights?	2.90	0.723	48	1.000	.962
21	(EC1)43	Workers anchoring their safety harnesses?	2.82	0.701	63	1.000	.938
22	(EC1)44	Workers using suitable PPE as per the hazards?	2.90	0.706	49	1.000	.966
23	(EC1)48	Porkers lifting proper weights?	2.92	0.704	46	1.000	.941
24	(EC1)49	Workmen trained in material handling?	3.21	0.705	1	1.000	.892
25	(EC1)52	Proper flooring done with adequate load bearing capacity?	3.14	0.684	3	1.000	.925
26	(EC1)53	Adequate place for bulk storage of construction materials?	3.02	0.693	34	1.000	.851
27	(EC1)54	Stacks protected from collapse?	3.02	0.703	33	1.000	.835
28	(EC1)55	Material protected from weather and rain?	3.10	0.69	14	1.000	.929
29	(EC1)62	Flame cutting and welding taking place with proper fire precautions?	3.07	0.713	24	1.000	.544
30	(EC1)63	Site entrance always clear for fire engines to get in?	2.83	0.705	58	1.000	.506
31	(EC1)64	Trained persons to fight fire?	3.13	0.697	4	1.000	.599
32	(EC1)67	Excavations sloped/ step back or shored properly?	2.64	0.682	78	1.000	.800
33	(EC1)68	Safe access provided for vehicles in excavation area?	2.90	0.709	50	1.000	.750
34	(EC1)69	Excavated material kept 1m away from the edge of excavation?	2.77	0.704	69	1.000	.855
35	(EC1)71	Excavations properly barricaded?	2.82	0.698	62	1.000	.778
36	(EC1)76	Excavations frequently inspected for cracks particularly after rains?	3.11	0.686	10	1.000	.833
37	(EC1)77	Entry of water into the pits checked and controlled?	3.10	0.694	20	1.000	.802
38	(EC1)78	Adequate precautions taken while removing the timber, supports etc..in side of pits?	3.08	0.693	21	1.000	.815
39	(EC1)81	Gas test conducted in confined space ?	3.10	0.677	15	1.000	.823
40	(EC1)82	Confined space entry procedures followed?	2.94	0.704	42	1.000	.797
41	(EC1)83	Workmen trained to work inside confined space?	3.10	0.688	19	1.000	.820
42	(EC1)84	Register maintained to enter the names while entering and leaving the confined space?	2.93	0.707	45	1.000	.816
43	(EC1)90	Cables protected from mechanical damages?	3.01	0.713	35	1.000	.593
44	(EC1)91	Insulations regularly inspected and records maintained?	3.05	0.711	29	1.000	.577
45	(EC1)92	Required fire extinguishers provided near the electrical panels?	2.95	0.704	41	1.000	.607
46	(EC1)93	Any artificial resuscitation charts displayed near electrical panels?	2.83	0.707	57	1.000	.420
Execution and Controlling Stage (Level-2)							
47	(EC2)94	Scaffolds designed as per the load requirement?	2.91	0.701	47	1.000	.759
48	(EC2)98	Handrails, mid rails and toe boards fixed for the platforms?	3.07	0.681	23	1.000	.881
49	(EC2)99	Proper access to reach the platforms?	3.10	0.693	16	1.000	.777
50	(EC2)100	Scaffolds base to height ratio maintained at 1:4?	2.94	0.713	43	1.000	.819
51	(EC2)107	Power cables and welding cables protected from mechanical damage?	3.12	0.704	9	1.000	.633
52	(EC2)110	Temporary screens provided to protect others from welding rays, grinding sparks?	3.11	0.708	11	1.000	.673
53	(EC2)111	Fire precautions taken against the falling of welding sparks?	2.96	0.726	40	1.000	.688
54	(EC2)112	Gas cylinders stored properly in vertical position and secured?	2.83	0.739	60	1.000	.566
55	(EC2)113	False work has been designed by a competent person?	3.05	0.72	30	1.000	.787
56	(EC2)114	Design been rechecked by the engineer concerned?	2.76	0.687	72	1.000	.764
57	(EC2)119	Proper walkway provided over the reinforcement bars?	3.00	0.715	37	1.000	.803
58	(EC2)120	Open edges properly barricaded wile false work?	2.80	0.697	64	1.000	.844

59	(EC2)121	Site specific fall protection plan in place?	2.83	0.686	59	1.000	.722
60	(EC2)122	Workers trained in the fall protection procedures?	3.05	0.719	28	1.000	.729
61	(EC2)125	Workers using full body harness?	3.00	0.717	38	1.000	.520
62	(EC2)126	Workers anchored safety harness to a strong anchoring point?	2.85	0.721	54	1.000	.734
63	(EC2)127	Lifelines provided where anchoring points?	2.78	0.702	67	1.000	.519
Execution and Controlling Stage (Level-3)							
64	(EC3)135	Are the power tools provided with earth connection?	3.13	0.713	5	1.000	.764
65	(EC3)136	Power tools handled properly?	3.10	0.705	18	1.000	.535
66	(EC3)137	Handles of the tools free from splits and cracks?	2.85	0.704	55	1.000	.594
67	(EC3)138	Vehicles inspected and the license is current?	2.76	0.708	71	1.000	.848
68	(EC3)139	Seat belts provided and are in use by the users?	3.08	0.708	22	1.000	.834
69	(EC3)143	Parking brakes applied when vehicles not in use?	2.77	0.697	68	1.000	.823
70	(EC3)144	Vehicles properly covered while carrying loose materials	2.99	0.724	39	1.000	.853
71	(EC3)147	Bench mounted drilling machines firmly secured to a strong and stable bench?	2.77	0.695	70	1.000	.884
72	(EC3)150	The small work piece held in a vice or clamp?	3.00	0.72	36	1.000	.817
73	(EC3)151	Operators wearing fit clothing and gloves, etc.. While operating the machine?	2.75	0.703	74	1.000	.711
74	(EC3)152	Grinding machines wheels adequately guarded?	2.74	0.702	76	1.000	.881
75	(EC3)154	Grinding machines wheels fitted as per the designed speed and correctly fitted on the spring wheel?	2.83	0.702	61	1.000	.881
76	(EC3)155	RPM clearly marked on the grinding machine?	3.03	0.708	32	1.000	.891
77	(EC3)160	Riving knife provided to prevent kick back?	3.03	0.693	31	1.000	.842
78	(EC3)161	Area around the machine neat and tidy?	2.73	0.693	77	1.000	.458

Table 2: Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.801
Bartlett's Test of Sphericity	Approx. Chi-Square	31992.549
	Df	3003
	Sig. (p)	0.000

According to Tabachnick and Fidell, the Bartlett‘s test of Sphericity should be significant ($p < 0.05$) for the factor analysis to be considered appropriate. In this study, the Kaiser-Meyer-Olkin (KMO) value was 0.801 and the Bartlett‘s test of Sphericity is significant ($p=0.00$), therefore, conducting a factor analysis was deemed appropriate (Table 2). Table 3 shows the initial eigenvalues, percentages of variance explained, and cumulative percentages for the extracted factors. The total variance explained by each component extracted was as follows; component 1 (23.202%), component 2 (11.076), component 3 (5.809), component 4 (3.827), component 5 (3.202), component 6 (3.010), component 7 (2.862), component 8 (2.662), component 9 (2.659), component 10 (2.552), component 11 (2.537), component 12 (2.494), component 13 (2.455), component 14 (2.384) and component 15 (2.187). Fifteen common factors out of 78 variables were extracted through factor analysis with the cumulative up to 72.917%.

Table 3: Total Variance Explained

Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	18.180	23.308	23.308	18.180	23.308	23.308	18.097	23.202	23.202
2	8.790	11.269	34.577	8.790	11.269	34.577	8.639	11.076	34.278
3	4.569	5.857	40.435	4.569	5.857	40.435	4.531	5.809	40.087
4	3.283	4.209	44.643	3.283	4.209	44.643	2.985	3.827	43.913
5	2.968	3.805	48.449	2.968	3.805	48.449	2.497	3.202	47.115

6	2.715	3.481	51.930	2.715	3.481	51.930	2.348	3.010	50.125
7	2.381	3.053	54.983	2.381	3.053	54.983	2.232	2.862	52.987
8	2.300	2.949	57.931	2.300	2.949	57.931	2.077	2.662	55.649
9	2.066	2.649	60.581	2.066	2.649	60.581	2.074	2.659	58.308
10	1.917	2.458	63.039	1.917	2.458	63.039	1.990	2.552	60.860
11	1.810	2.321	65.360	1.810	2.321	65.360	1.979	2.537	63.397
12	1.581	2.027	67.386	1.581	2.027	67.386	1.945	2.494	65.891
13	1.516	1.944	69.330	1.516	1.944	69.330	1.915	2.455	68.346
14	1.459	1.871	71.201	1.459	1.871	71.201	1.860	2.384	70.730
15	1.338	1.716	72.917	1.338	1.716	72.917	1.706	2.187	72.917

Based on an examination of the inherent relationships among the variables under each component, the following interpretation was made component 1 was termed management support and workers' responsibilities, component 2 was termed prevention of fire and excavation hazards, component 3 was termed proper materials handling and storage methods, component 4 was termed fall prevention and protection, component 5 was termed precaution activities for formwork and concreting, component 6 was termed prevention of electrical hazards, component 7 was termed standard methods and maintenance of confined space, component 8 was termed scaffolding and working platform standards, component 9 was termed hazard prevention from welding and grinding, component 10 was termed hazard prevention from hand tools and power tools, component 11 was termed grinding machine and operator standards, component 12 was termed motor vehicle rules, component 13 was termed drilling machine and operator standards, component 14 was termed hazard prevention methods for scaffolding, gas cutting and vehicles, component 15 was termed precaution and maintenance of woodworking machines. These names were derived from the components using the variables with the loading factor. Figure 3 shows the total variance associated with each factor.

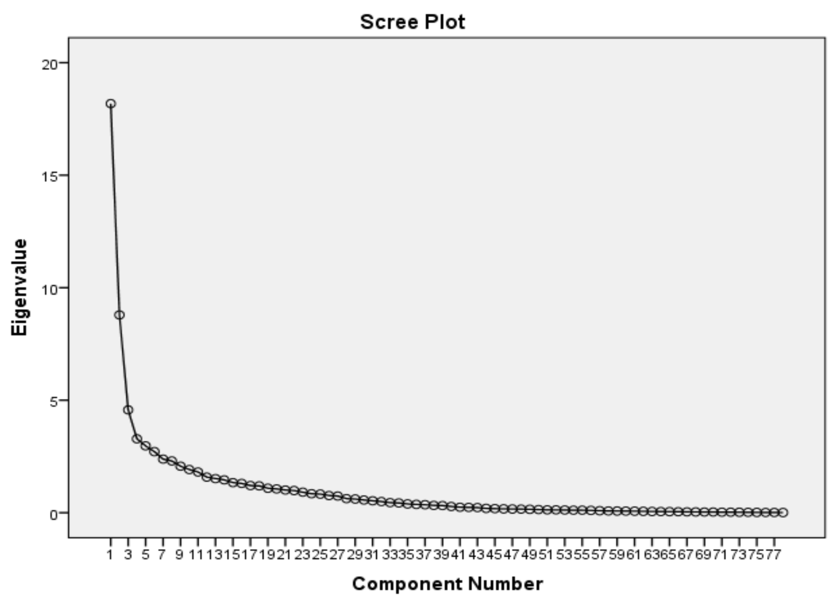

Figure 3: Total Variance Associated with Each Factor

Factor analysis was then used to reduce the surveyed information to a factor structure consisting of a cluster of factors. Factor analysis not only extracted and interpreted these key factors that dominate the workplace safety on construction sites (i.e. factor loading) to measure their safety performance. Table 4 shows the list of initial factors included under underlying extracted factors.

Table 4: List of Initial Factors included under underlying Extracted Factors

Factor No.	Initial Factor		Factor Loading
Factor-1	**Management support and workers' responsibilities.**		
Percentage of Variance Explained=23.202		**Cumulative % of Variance Explained=23.202**	
PS28	Special storage areas for petrol, flammable materials, explosives etc…?		.980
(EC1)44	Workers using suitable PPE as per the hazards?		.979
PS27	Scrap dump areas?		.979
(EC1)42	Workers wearing full body safety harness while working at heights?		.977
PS29	Access roads suitable for the movement of plant and vehicles?		.974
(EC1)43	Workers anchoring their safety harnesses?		.966
PS30	Ambulance room / emergency vehicle suitable located?		.947
IS6	Safety committee?		.936
IS3	Safety plans and safety procedures?		.928
IS10	Safety material displayed on the site?		.925
IS7	Employees given safety orientation?		.924
PS19	Emergency telephone numbers displayed?		.922
IS2	Everyone aware of the contents of the safety policy?		.922
PS15	Qualified doctor/nurse available on site?		.898
IS8	Employees given specialized training where needed?		.895
PS18	Workers aware of the emergency procedures?		.895
PS35	Local scrap yard provided?		.886
PS17	Team trained in emergency response procedures?		.886
PS16	Any arrangement with hospital for emergency treatment?		.883
PS31	Site kept neat and tidy?		.798
PS39	An easy access to Electrical control panels, Fire extinguishers, First Aid boxes etc…?		.782
PS34	Materials and equipments stored properly?		.731
Factor-2	**Prevention of fire and excavation hazards.**		
Percentage of Variance Explained=11.076		**Cumulative % of Variance Explained=34.278**	
(EC1)76	Excavations frequently inspected for cracks particularly after rains?		.967
(EC1)69	Excavated material kept 1m away from the edge of excavation?		.954
(EC1)78	Adequate precautions taken while removing the timber, supports etc..in side of pits?		.906
(EC1)77	Entry of water into the pits checked and controlled?		.893
(EC1)67	Excavations sloped/ step back or shored properly?		.867
(EC1)71	Excavations properly barricaded?		.866
(EC1)68	Safe access provided for vehicles in excavation area?		.837
(EC1)64	Trained persons to fight fire?		.799
(EC1)63	Site entrance always clear for fire engines to get in?		.541
(EC1)62	Flame cutting and welding taking place with proper fire precautions?		.401
Factor-3	**Proper materials handling and storage methods.**		
Percentage of Variance Explained=5.809		**Cumulative % of Variance Explained=40.087**	
(EC1)48	Porkers lifting proper weights?		.911
(EC1)55	Material protected from weather and rain?		.901
(EC1)52	Proper flooring done with adequate load bearing capacity?		.890
(EC1)49	Workmen trained in material handling?		.881
(EC1)53	Adequate place for bulk storage of construction materials?		.820
(EC1)54	Stacks protected from collapse?		.799
Factor-4	**Fall prevention and protection.**		
Percentage of Variance Explained=3.827		**Cumulative % of Variance Explained=43.913**	
(EC2)126	Workers anchored safety harness to a strong anchoring point?		.954
(EC2)122	Workers trained in the fall protection procedures?		.901
(EC2)127	Lifelines provided where anchoring points?		.686
(EC2)125	Workers using full body harness?		.642
(EC2)121	Site specific fall protection plan in place?		.526
Factor-5	**Precaution activities for formwork and concreting.**		
Percentage of Variance Explained=3.202		**Cumulative % of Variance Explained=47.115**	
(EC2)120	Open edges properly barricaded wile false work?		.938
(EC2)119	Proper walkway provided over the reinforcement bars?		.863
(EC2)113	False work has been designed by a competent person?		.859
(EC2)114	False work design been rechecked by the engineer concerned?		.755
Factor-6	**Prevention of electrical hazards.**		
Percentage of Variance Explained=3.010		**Cumulative % of Variance Explained=50.125**	
(EC1)90	Cables protected from mechanical damages?		.903
(EC1)92	Required fire extinguishers provided near the electrical panels?		.895
(EC1)91	Insulations regularly inspected and records maintained?		.884
(EC1)93	Any artificial resuscitation charts displayed near electrical panels?		.522
Factor-7	**Standard methods and maintenance of confined space.**		
Percentage of Variance Explained=2.862		**Cumulative % of Variance Explained=52.987**	
(EC1)83	Workmen trained to work inside confined space?		.902

(EC1)81	Gas test conducted in confined space ?	.810
(EC1)84	Register maintained to enter the names while entering and leaving the confined space?	.719
(EC1)82	Confined space entry procedures followed?	.454
Factor-8	**Scaffolding and working platform standards.**	
Percentage of Variance Explained=2.662	**Cumulative % of Variance Explained=55.649**	
(EC2)98	Handrails, mid rails and toe boards fixed for the platforms?	.934
(EC2)100	Scaffolds base to height ratio maintained at 1:4?	.899
(EC2)99	Proper access to reach the platforms?	.874
Factor-9	**Hazard prevention from welding and grinding.**	
Percentage of Variance Explained=2.659	**Cumulative % of Variance Explained=58.308**	
(EC2)110	Temporary screens provided to protect others from welding rays, grinding sparks?	.929
(EC2)111	Fire precautions taken against the falling of welding sparks?	.830
(EC2)107	Power cables and welding cables protected from mechanical damage?	.448
Factor-10	**Hazard prevention from hand tools and power tools.**	
Percentage of Variance Explained=2.552	**Cumulative % of Variance Explained=60.860**	
(EC3)135	Are the power tools provided with earth connection?	.923
(EC3)136	Power tools handled properly?	.878
(EC3)137	Handles of the tools free from splits and cracks?	.437
Factor-11	**Grinding machine and operator standards.**	
Percentage of Variance Explained=2.537	**Cumulative % of Variance Explained=63.397**	
(EC3)154	Grinding machines wheels fitted as per the designed speed and correctly fitted on the spring wheel?	.920
(EC3)152	Operators wearing fit clothing and gloves, etc.. While operating the machine?	.884
(EC3)155	RPM clearly marked on the grinding machine?	.427
Factor-12	**Motor vehicle rules.**	
Percentage of Variance Explained=2.494	**Cumulative % of Variance Explained=65.891**	
(EC3)144	Vehicles properly covered while carrying loose materials?	.913
(EC3)139	Seat belts provided and are in use by the users?	.863
(EC3)138	Vehicles inspected and the license is current?	.473
Factor-13	**Drilling machine and operator standards.**	
Percentage of Variance Explained=2.455	**Cumulative % of Variance Explained=68.346**	
(EC3)147	Bench mounted drilling machines firmly secured to a strong and stable bench?	.904
(EC3)150	The small work piece held in a vice or clamp?	.799
(EC3)151	Operators wearing fit clothing and gloves, etc.. While operating the machine?	.497
Factor-14	**Hazard prevention methods for scaffolding, gas cutting and vehicles.**	
Percentage of Variance Explained=2.384	**Cumulative % of Variance Explained=70.730**	
(EC2)94	Scaffolds designed as per the load requirement?	.864
(EC3)143	Parking brakes applied when vehicles not in use?	.854
(EC2)112	Gas cylinders stored properly in vertical position and secured?	.527
Factor-15	**Precaution and maintenance of woodworking machines**	
Percentage of Variance Explained=2.187	**Cumulative % of Variance Explained=72.917**	
(EC3)160	Riving knife provided to prevent kick back?	.897
(EC3)161	Area around the machine neat and tidy?	.596

The percentage of variance and cumulative percentage of variance were tabulated. The total cumulative percentage of variance explained was 72.917%. Factor 1 (Component 1) was a management support and workers' responsibilities related factors. Factor 2 (Component 2) was a prevention of fire and excavation hazards related factors. Factor 3 (Component 3) was a proper materials handling and storage methods related factors. Factor 4 (Component 4) was fall prevention and protection related factors. Factor 5 (Component 5) was a precaution activity for formwork and concreting related factors. Factor 6 (Component 6) was a prevention of electrical hazards related factors. Factor 7 (Component 7) was a standard methods and maintenance of confined space related factor. Factor 8 (Component 8) was scaffolding and working platform standards related factors. Factor 9 (Component 9) was hazard prevention from welding and grinding related factors. Factor 10 (Component 10) was hazard prevention from hand tools and power tools related factors. Factor 11 (Component 11) was grinding machine and operator standards related factors. Factor 12 (Component 12) was motor vehicle rules related factors. Factor 13 (Component 13) was drilling machine and operator standards related factors. Factor 14 (Component 14) was a hazard prevention method for scaffolding related factors. Factor 13 was gas cutting and vehicles related factors. Factor 15(Component 15) was a precaution and maintenance of woodworking machines related factors.

5. CONCLUSIONS

Based on the factor analysis and results obtained from the respondents through questionnaire survey, the following critical factors are found to significantly influence the aspect of safety at construction sites:

- Lack of management support and workers' responsibilities.
- Lack of knowledge about prevention of fire and excavation hazards.
- Lack of proper materials handling and storage methods.
- Lack of knowledge about fall prevention and protection.
- Lack of precaution activities for formwork and concreting.
- Lack of prevention of electrical hazards.
- Lack of knowledge about standard methods and maintenance of confined space.
- Lack of knowledge about scaffolding and working platform standards.
- Lack of knowledge about hazard prevention from welding and grinding.
- Lack of knowledge about hazard prevention from hand tools and power tools.
- Lack of "grinding machine and operator" standards.
- Lack of knowledge about motor vehicle rules.
- Lack of "drilling machine and operator" standards.
- Lack of hazard prevention methods for scaffolding, gas cutting and vehicles.
- Lack of knowledge about precaution and maintenance of woodworking machines

Furthermore importing safety policy and standards, safety organization, safety training, inspecting hazardous conditions, personal protection program, plant and equipment, safety promotion, and management behavior also help in ensuring safety at construction sites.

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