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A Study on Safety Management in Construction Projects

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Abstract - This paper presents a study in construction industry to improve the safety performance. The main objective of this study is to identify the critical success factors which are responsible for the implementation of safety management in construction projects. This study was carried out by conducting questionnaire survey among the contractors and clients of various construction projects, for testing their experience in safety management system. Questionnaire survey was analysed using SPSS software. The results of the study revealed that there are many safety problems in the construction industry, such as lack of knowledge about the necessity of earth connection for power tools and lack of knowledge about cables protect from mechanical damages. Furthermore, the study also proposes some recommendations for safety in construction industry.

Index terms: **Critical Success Factor, Descriptive Statistics, Safety management, SPSS.**

I. INTRODUCTION

The purpose of this paper is to utilize discriptive analysis to benchmark safety performance of construction contractors and clients. SPSS has been recognized as a robust tool for evaluating the performance of organizations such as business firms, hospitals, government agencies, educational institutions, etc. SPSS is well employed in other industries.

Construction in developing countries such as India is more labor-intensive than that in the developed areas of the globe. In numerous developing countries such as India, there is a significant difference between large and small contractors. Most large firms do have a safety policy, on paper, but employees generally are not aware of its existence. Nevertheless, a number of major constructors exhibit a concern for safety and have established various safety procedures. They also provide training for workers and maintain safety personnel at the job site.
One method that may be used to increase site safety is to involve employees in developing a safety program. Many employees are aware of significantly more field hazards than their employers and can suggest ideas which will reduce accidents. In addition, by involving employees in planning, safety orientation, and training process, they become aware that they are executing their own safety program. Also, individuals may be recognized for maintaining a good safety record. In addition, designers can play an important role in reducing accidents, thereby providing a safer work place for construction personnel. Worker safety should be considered during the design process and, ideally, should be continuously updated during actual construction operations. It must be recognized that design decisions have an impact on job-site safety.

Jaselskis and Recarte Suazo[1] (1993) conducted a survey of construction site safety in Honduras. A questionnaire was used to collect safety-related information from construction workers, field management and upper management in the Home Office on residential, commercial and heavy civil construction projects in San Pedro Sula, Honduras. Data were collected using face-to-face interviews - 108 construction workers, 10 field managers and 8 senior managers participated. Data were analysed using correlation, regression and analysis of variance techniques. Results demonstrated a substantial lack of awareness or importance for safety at all levels of the construction organization. Workers rarely wore personal protective equipment, used poorly constructed scaffolds, improperly used tools and ladders and disregarded good housekeeping practices. Almost three quarters of the craftsmen suffered at least one lost-time accident; many of their injuries were in expected locations on their bodies given the nature of their work and the site conditions. Many of the field project managers stated that they did not provide workers with personal protective equipment or safety training and did not use a dedicated safety person on-site. Top level management does not appear convinced that it is in their best interests to improve safety performance since only approximately 25% provided a company-wide safety training programme, maintained accident records and provided safety incentives. Additional results,

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recommendations for improving construction safety in Honduras, study limitations and future research areas were also identified.

Mohamed[2] (1999) conducted an empirical investigation of construction safety management activities and performance in Australia. He investigated the effectiveness of safety management activities currently adopted by Australian contracting organizations. A safety management survey has been conducted in the contracting organizations operating in the State of Queensland, Australia. Based on a research model depicting statistical analysis techniques, a safety management index reflecting the intensity of level of safety management activities has been developed to provide a means whereby individual organizations can be assessed and graded on their safety management commitment and attitudes. The author reported a detailed empirical analysis carried out to examine the relationship between the intensity of safety management commitment and the overall safety performance, pro- activeness and record.

Fang, Huang and Hinze[4] (2004) conducted a Benchmarking Study on Construction Safety Management in China. This paper presents information to measure safety management performance on construction sites. In China, the conventional construction safety benchmarking approach was to assess safety performance by evaluating the physical safety conditions on site as well as the accident records, while no attention has been paid to the management factors that influence site safety. The authors identified key factors that influence safety management and developed a method for measuring safety management performance on construction sites. Based on the survey and interview, data collected on safety management factors in 82 construction projects in China, the safety management index as a means to evaluate real-time safety management performance by measuring key management factors was developed. The quantified factors were compared with the commonly accepted physical safety performance index, which was derived from inspection records of physical safety conditions, accident rates, and the satisfaction of the project management team. Multifactor linear regression was conducted and the results indicate that the safety management performance on site was closely related to organizational factors, economic factors, and factors related to the relationship between management and labor on site. Based on this benchmarking study, a practical safety assessment method was developed and then implemented on six construction projects. The author concluded that this method can be an effective tool to evaluate safety management on construction projects.

Hassanein and Hanna[6] (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 out of the surveyed sample had accident records broken down by projects and provided workers with formal safety orientation. 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 is meant to serve as a strong incentive for safety management.

Choudhry and Fang[7] (2008) carried out a research on the behavior focus and found that workers are involved in unsafe behavior because of lack of safety awareness, putting on a tough image, work pressure, co-workers' attitudes, organizational, economic and psychological factors. The author suggested recommendations for improving site safety by listening to the viewpoints of the subcontractor's workers. The reason behind this was that the subcontractors deal with different situations that judge their action on how best to work safely on a construction project. The objective was broken down into three parts: workers viewpoint, unsafe behaviors and safety behavior. The author's goal was to understand the workers viewpoint as to why accidents happen and this was accomplished by performing in-depth interviews with workers. Gaining understanding of why construction workers engage in unsafe work behavior and identifying factors that influence their safety behavior was part of their study.

Lopez, Ritzel, Fontaneda and Alcantara[8] (2008) conducted a study on construction industry accidents in spain. They analyzed industrial accidents that take place on construction sites and their severity. Eighteen variables were studied. They analyzed the influence of each of these with respect to severity and fatality of the accident. The descriptive analysis was grounded in 1,630,452 accidents, representing the total number of accidents suffered by workers in the construction sector in Spain over the period 1990-2000. The authors concluded that

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age, type of contract, time of accident, length of service in the company, company size, day of the week, and influenced the seriousness of the accident. The research provided an insight into the likely causes of construction injuries in Spain. As a result of the analysis, industries and governmental agencies in Spain started to provide appropriate strategies and training to the construction workers.

Zubair, Kanya Lal And Allah Bux[9] (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 author finding that management support is the critical factor for implementing the 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).

Carcano and Franco-Poot[10] (2014) studied the Construction Workers' Perceptions of Safety Practices: A Case Study in Mexico. Organizational characteristics and worker perceptions were among the main factors affecting the safety climate in construction sites. Although some perceptions of workers may seem absurd to others, these components were part of their reality. Worker behavior was an extremely important factor in workplace safety as many accidents were often caused by insecure actions, in which combinations of human behavior were the consequence of such perceptions. The aim of this study was to explore workers' perceptions of safety practices in their habitual work environment, a building site in Mexico. Worker perceptions of safety practices were captured using an instrument in which the following dimensions were taken into consideration: Education and training, Work motivation, Family and social integration, Work place integration, Safety awareness integration, and Accidents. The authors concluded that workers have received very little education and possess a limited culture of safety awareness, which led them to perceive that their lack of precaution was the main cause of accidents.

II. MATERIALS AND METHODS

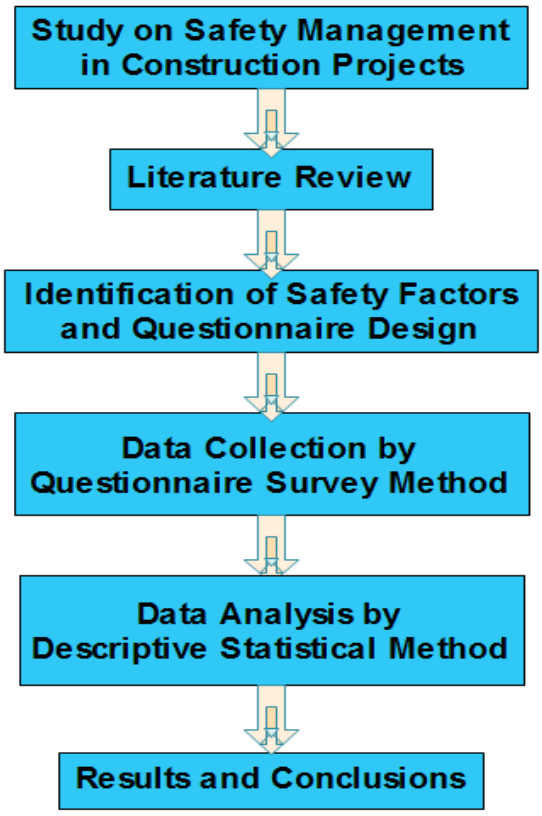

Fig.1 Methodology of the Study

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The study adopted questionnaire survey as a method to identify the underlying factors affecting the safety in construction projects. Survey through questionnaires were 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. Questionnaires were framed for the survey based on identifying the critical factors. The methodology of the study is as presented in Fig.1.

The questionnaire were prepared and sent to two main individuals responsible for the project (Contractor and Client) and the effect of each factor has been evaluated by adopting a five-point likert scale of 1 to 5. These numerical values are assigned to the respondents' rating: '1 = Strongly Agree; 2 = Agree; 3 = Neutral; 4 = Disagree; and 5 = Strongly Disagree;' for severity. Among 400 questionnaires sent to construction professionals for investigation, 324 questionnaires were completed and returned by respondents, After eliminating incomplete responses of the questionnaires, only 298 full responses were found to be properly completed and useful for analysis. Details of grouping aspects and related factors are given in Fig 2.

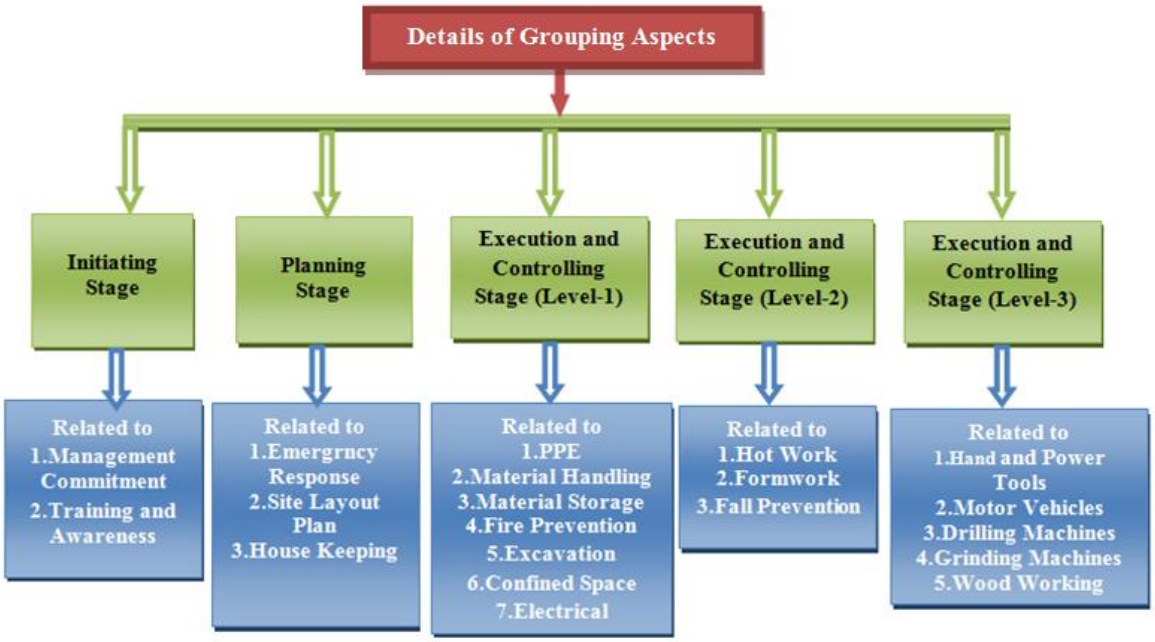

Fig. 2 Details of Grouping Aspects and Related Factors

III. METHOD OF ANALYSIS

To achieve the objectives of this study, mean and standard deviation values were calculated and rank were given to each factor accordingly. The significance of using ranking method identifies the importance of safety management in construction industry. A statistical test was conducted among the two respondent groups; contractors and clients using SPSS (Statistical Package for Social Sciences) software.

The rank for each technique was determined by using the mean and standard deviation values computed from the respondents' data. The questionnaire survey was conducted to determine the importance of critical success factors for safety management which was perceived by contractors and clients working within Construction Industry.

IV. RESULTS AND DISCUSSION

This section discusses the results of the collected data for critical success factors for the safety program implementation. The results of Mean, Standard Deviation (Std. Dev.) and Rank by respondent groups are summarized in Table 2. The rank was provided according to the higher mean value, if both the mean values are equal then we considered the lesser standard deviation value is taken as higher rank.

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Table 1. Descriptive Statistics Results of Respondent Groups

ID	Factor Name	Contractors Perspective (n = 159)			Client Perspective (n = 139)		
		Mean	Std. Dev.	Rank	Mean	Std. Dev.	Rank
	Initiating Stage						
IS1	Safety policy?	2.48	0.595	85	2.43	0.623	98
IS2	Everyone aware of the contents of the safety policy?	2.96	0.707	27	3.07	0.675	30
IS3	Safety plans and safety procedures?	2.94	0.705	31	3.09	0.674	23
IS4	Safety organization?	2.36	0.585	101	2.44	0.629	95
IS5	Competent safety professional available at site?	2.33	0.594	105	2.37	0.623	106
IS6	Safety committee?	3.01	0.698	10	3.10	0.56	19
IS7	Employees given safety orientation?	3.01	0.672	9	3.13	0.673	11
IS8	Employees given specialized training where needed?	2.99	0.664	13	3.14	0.676	10
IS9	Tool box talks regularly conducted?	2.55	0.613	79	2.42	0.616	101
IS10	Safety material displayed on the site?	2.99	0.682	14	3.12	0.669	14
IS11	Site safety instructions to various trades?	2.48	0.608	86	2.43	0.629	100
IS12	Method statements made for critical activities?	2.53	0.605	81	2.45	0.623	89
	Planning Stage						
PS13	First aid center at site?	2.06	0.573	136	1.88	0.483	149
PS14	First Aid Centre equipped with the required medicines and accessories?	1.85	0.447	148	1.81	0.454	157
PS15	Qualified doctor/nurse available on site?	2.74	0.674	57	2.78	0.686	69
PS16	Any arrangement with hospital for emergency treatment?	3.10	0.705	4	3.07	0.680	31
PS17	Team trained in emergency response procedures?	2.79	0.738	53	2.89	0.706	57
PS18	Workers aware of the emergency procedures?	2.84	0.729	48	2.94	0.695	49
PS19	Emergency telephone numbers displayed?	3.01	0.698	10	3.12	0.668	13
PS20	Emergency vehicle/ ambulance available on site?	2.04	0.507	140	2.09	0.553	129
PS21	Assembly points available?	2.04	0.555	141	1.88	0.488	150
PS22	Mock drills conducted at regular intervals?	1.86	0.463	146	1.81	0.460	158
PS23	Perimeter fencing arranged?	2.05	0.509	139	2.20	0.605	115
PS24	Access at the site entrances clearly visible?	2.18	0.592	116	2.32	0.620	109
PS25	Access wide enough to allow plant and personnel?	2.32	0.630	106	2.16	0.591	120
PS26	Sufficient lighting at the entrance?	2.31	0.606	108	2.16	0.604	120
PS27	Scrap dump areas?	2.91	0.694	38	2.75	0.725	71
PS28	Special storage areas for petrol, flammable materials, explosives etc…?	2.92	0.698	36	2.80	0.728	66
PS29	Access roads suitable for the movement of plant and vehicles?	2.90	0.689	39	2.73	0.707	72
PS30	Ambulance room/ emergency vehicle suitable located?	3.15	0.699	3	3.06	0.732	35
PS31	Site kept neat and tidy?	2.70	0.706	61	2.78	0.686	68
PS32	Proper arrangement for regular collection and disposal of waste materials?	1.74	0.440	155	1.96	0.543	142
PS33	Walkways clearly defined and unobstructed?	2.03	0.552	142	2.02	0.533	136
PS34	Materials and equipments stored properly?	2.98	0.715	22	3.09	0.717	27
PS35	Local scrap yard provided?	2.57	0.711	77	2.96	0.706	47
PS36	Adequate lightings provided for work areas and passages?	2.14	0.544	122	1.91	0.496	147
PS37	Toilets regularly cleaned?	1.85	0.488	149	1.95	0.494	143
PS38	Adequate water supply for sanitation?	2.14	0.526	119	2.11	0.560	126
PS39	An easy access to Electrical control panels, Fire extinguishers, First Aid boxes etc…?	2.58	0.745	75	2.83	0.709	61
	Execution and Controlling Stage (Level-1)						
(EC1)40	Everyone wearing safety shoes while on site?	2.45	0.589	91	2.46	0.629	86
(EC1)41	Workers wearing suitable hand gloves while handling rough objects, chemicals etc..?	2.53	0.605	81	2.46	0.618	85

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(EC1)42	Workers wearing full body safety harness while working at heights?	2.92	0.711	37	2.80	0.750	67
(EC1)43	Workers anchoring their safety harnesses?	2.86	0.692	42	2.73	0.729	73
(EC1)44	Workers using suitable PPE as per the hazards?	2.92	0.693	35	2.81	0.734	65
(EC1)45	PPE regularly inspected for there good condition?	2.43	0.594	95	2.47	0.635	83
(EC1)46	Proper lifting accessories for manual handling provided?	2.53	0.595	80	2.43	0.620	97
(EC1)47	Personnel using body mechanics when lifting and carrying?	2.53	0.595	80	2.43	0.617	96
(EC1)48	Porkers lifting proper weights?	2.95	0.700	30	2.82	0.730	64
(EC1)49	Workmen trained in material handling?	3.21	0.705	1	3.12	0.730	15
(EC1)50	Lifting and carrying accessories provided for manual handling?	2.43	0.589	94	2.47	0.629	81
(EC1)51	Materials stored in an orderly manner?	2.35	0.611	102	2.40	0.616	103
(EC1)52	Proper flooring done with adequate load bearing capacity?	3.16	0.672	2	3.11	0.678	17
(EC1)53	Adequate place for bulk storage of construction materials?	2.87	0.675	41	3.09	0.699	24
(EC1)54	Stacks protected from collapse?	2.86	0.697	43	3.09	0.700	25
(EC1)55	Material protected from weather and rain?	3.08	0.683	6	3.11	0.701	18
(EC1)56	Adequate ventilation?	2.17	0.596	118	2.14	0.585	121
(EC1)57	Fire precautions taken where flammable materials stored?	2.01	0.558	143	2.12	0.612	124
(EC1)58	waste accumulating in hoist shafts, corners etc…?	1.81	0.508	153	1.86	0.495	154
(EC1)59	Safe ash trays provided where smoking is allowed?	1.87	0.518	145	1.88	0.498	151
(EC1)60	Electrical circuits free from overloaded?	1.86	0.480	147	1.94	0.501	144
(EC1)61	Fire extinguishers available on site?	1.81	0.469	152	1.94	0.538	145
(EC1)62	Flame cutting and welding taking place with proper fire precautions?	2.98	0.708	21	3.16	0.730	9
(EC1)63	Site entrance always clear for fire engines to get in?	2.63	0.660	70	3.05	0.728	38
(EC1)64	Trained persons to fight fire?	2.95	0.682	29	3.32	0.697	1
(EC1)65	Method statement made for excavation?	1.82	0.474	151	2.08	0.532	130
(EC1)66	Excavation permit taken where needed?	1.84	0.415	150	1.90	0.452	148
(EC1)67	Excavations sloped/ step back or shored properly?	2.52	0.677	82	2.65	0.686	75
(EC1)68	Safe access provided for vehicles in excavation area?	2.79	0.719	51	2.91	0.708	55
(EC1)69	Excavated material kept 1m away from the edge of excavation?	2.79	0.731	52	2.65	0.686	76
(EC1)70	Excavation edge free from falling material?	1.79	0.440	154	1.81	0.453	156
(EC1)71	Excavations properly barricaded?	2.59	0.676	73	2.91	0.752	56
(EC1)72	Dewatering done where needed in the pits?	1.79	0.440	154	1.97	0.521	140
(EC1)73	Precautions taken against material falling on the persons working in the pits?	2.3	0.657	109	2.33	0.624	108
(EC1)74	Adequate precautions taken against electrical hazards in the pits?	2.06	0.615	137	1.83	0.453	155
(EC1)75	Adequate lighting in case of night work in the pits?	2.08	0.624	134	1.93	0.524	146
(EC1)76	Excavations frequently inspected for cracks particularly after rains?	3.00	0.720	11	3.11	0.667	16
(EC1)77	Entry of water into the pits checked and controlled?	2.97	0.730	25	3.09	0.670	22
(EC1)78	Adequate precautions taken while removing the timber, supports etc..in side of pits?	2.97	0.733	26	3.08	0.670	28
(EC1)79	Confined space free from toxic gases and oxygen deficiency?	2.38	0.615	99	2.27	0.624	112
(EC1)80	Proper access for entry and exit confined space?	2.08	0.677	135	2.19	0.589	116
(EC1)81	Gas test conducted in confined space ?	2.99	0.703	15	3.09	0.662	21
(EC1)82	Confined space entry procedures followed?	2.84	0.720	47	2.96	0.699	46
(EC1)83	Workmen trained to work inside confined space?	2.99	0.721	18	3.10	0.560	19
(EC1)84	Register maintained to enter the names while	2.85	0.727	45	2.91	0.698	53

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	entering and leaving the confined space?						
(EC1)85	Proper communication system for the person working inside the confined space?	2.38	0.615	99	2.45	0.668	92
(EC1)86	Electrical installation made as per the load requirement?	2.47	0.653	90	2.19	0.644	117
(EC1)87	Installation certified by a licensed supervisor?	2.23	0.657	114	2.27	0.621	111
(EC1)88	ELCBs/ MCBs provided in the circuit?	2.25	0.646	113	2.19	0.648	118
(EC1)89	Distribution boards protected from rain and water?	2.27	0.618	110	2.26	0.632	113
(EC1)90	Cables protected from mechanical damages?	2.99	0.710	17	3.02	0.723	42
(EC1)91	Insulations regularly inspected and records maintained?	3.02	0.706	8	3.06	0.703	33
(EC1)92	Required fire extinguishers provided near the electrical panels?	2.77	0.709	54	3.08	0.681	29
(EC1)93	Any artificial resuscitation charts displayed near electrical panels?	2.69	0.711	62	3.01	0.708	43
	Execution and Controlling Stage (Level-2)						
(EC2)94	Scaffolds designed as per the load requirement?	2.75	0.715	56	2.96	0.690	45
(EC2)95	Scaffolds erected under the supervision of a trained person?	2.19	0.602	115	2.17	0.592	119
(EC2)96	Scaffolds erected on level ground with proper sole boards and base plates?	2.25	0.614	112	2.22	0.608	114
(EC2)97	Platform boards inspected and are in good condition?	2.31	0.577	107	2.50	0.632	79
(EC2)98	Handrails, mid rails and toe boards fixed for the platforms?	2.97	0.709	23	3.04	0.667	39
(EC2)99	Proper access to reach the platforms?	2.97	0.724	24	3.08	0.670	28
(EC2)100	Scaffolds base to height ratio maintained at 1:4?	2.83	0.736	49	2.94	0.692	48
(EC2)101	Scaffold permits taken before using?	2.18	0.606	117	2.34	0.682	107
(EC2)102	Red / Green tags attached as per the conditions of the scaffolds?	2.45	0.602	93	2.46	0.629	86
(EC2)103	Castor wheels of mobile scaffolds properly locked?	2.43	0.589	94	2.45	0.611	88
(EC2)104	Good condition of welding cables ?	2.13	0.542	124	2.27	0.607	110
(EC2)105	Lugs used for cable connection?	2.11	0.526	129	2.08	0.535	131
(EC2)106	Welding transformers properly earthed?	2.38	0.586	97	2.40	0.624	104
(EC2)107	Power cables and welding cables protected from mechanical damage?	3.08	0.677	5	3.18	0.720	8
(EC2)108	Welders using welding hoods attached to safety helmets?	2.38	0.592	98	2.44	0.617	93
(EC2)109	Welders using required PPE?	2.14	0.535	121	2.07	0.541	132
(EC2)110	Temporary screens provided to protect others from welding rays, grinding sparks?	3.00	0.748	12	3.20	0.681	2
(EC2)111	Fire precautions taken against the falling of welding sparks?	2.83	0.740	50	2.99	0.712	44
(EC2)112	Gas cylinders stored properly in vertical position and secured?	2.69	0.759	63	3.04	0.718	40
(EC2)113	False work has been designed by a competent person?	2.94	0.723	32	3.19	0.729	5
(EC2)114	False work design been rechecked by the engineer concerned?	2.66	0.679	65	2.91	0.699	54
(EC2)115	Any additional load on the false work due to plant and storage of materials?	2.57	0.602	76	2.43	0.626	99
(EC2)116	Proper electrical connection for the vibrators?	2.05	0.493	138	1.99	0.518	138
(EC2)117	Workers using PPE at the time of concreting?	2.26	0.599	111	2.11	0.619	127
(EC2)118	Using Gum boots while working on wet concrete?	2.14	0.526	119	1.98	0.519	139
(EC2)119	Proper walkway provided over the reinforcement bars?	2.88	0.758	40	3.10	0.682	20
(EC2)120	Open edges properly barricaded wile false work?	2.66	0.722	66	2.91	0.681	52
(EC2)121	Site specific fall protection plan in place?	2.60	0.673	72	3.03	0.684	41
(EC2)122	Workers trained in the fall protection procedures?	2.99	0.755	19	3.05	0.695	37
(EC2)123	Open edges and floor cut outs properly barricaded?	2.47	0.600	89	2.48	0.644	80

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(EC2)124	Staircases provided with temporary railings?	2.11	0.514	128	2.11	0.56	125
(EC2)125	Workers using full body harness?	2.93	0.718	33	3.09	0.708	26
(EC2)126	Workers anchored safety harness to a strong anchoring point?	2.77	0.776	55	2.93	0.688	50
(EC2)127	Lifelines provided where anchoring points?	2.66	0.724	67	2.83	0.680	60
(EC2)128	Fall arresters provided while climbing rope ladders?	2.45	0.600	92	2.45	0.638	91
(EC2)129	Safety nets fixed where needed?	2.09	0.521	131	2.13	0.561	122
	Execution and Controlling Stage (Level-3)						
(EC3)130	Hand tools in good working condition?	2.12	0.514	125	1.86	0.439	153
(EC3)131	Tools stored in a proper manner?	2.33	0.573	103	2.50	0.627	78
(EC3)132	Damaged tools removed from use?	2.10	0.537	130	2.06	0.536	133
(EC3)133	Appropriate tools available for the job?	2.37	0.581	100	2.47	0.632	82
(EC3)134	Grinding machines provided with guards over the wheels?	1.93	0.471	144	1.87	0.399	152
(EC3)135	Are the power tools provided with earth connection?	3.06	0.755	7	3.18	0.671	6
(EC3)136	Power tools handled properly?	2.92	0.680	34	3.19	0.727	4
(EC3)137	Handles of the tools free from splits and cracks?	2.65	0.687	68	3.06	0.725	34
(EC3)138	Vehicles inspected and the license is current?	2.72	0.746	59	2.83	0.670	59
(EC3)139	Seat belts provided and are in use by the users?	2.96	0.747	28	3.18	0.682	7
(EC3)140	All operators and drivers have valid licenses?	2.33	0.581	104	2.46	0.639	87
(EC3)141	Speed limit boards displayed on the site?	2.13	0.537	123	2.06	0.531	134
(EC3)142	Movements of vehicles controlled?	2.48	0.618	87	2.43	0.620	97
(EC3)143	Parking brakes applied when vehicles not in use?	2.73	0.739	58	2.83	0.654	58
(EC3)144	Vehicles properly covered while carrying loose materials	2.86	0.756	44	3.06	0.692	32
(EC3)145	Adequate precautions taken while removing damaged wheels and detachable flanges etc…?	2.40	0.593	96	2.45	0.626	90
(EC3)146	Tyres pressure maintained at manufacturers recommendations?	2.12	0.529	126	2.00	0.532	137
(EC3)147	Bench mounted drilling machines firmly secured to a strong and stable bench?	2.58	0.687	74	2.82	0.692	63
(EC3)148	Drilling area bench firmly fixed to the floor?	2.4	0.593	96	2.52	0.624	77
(EC3)149	The correct chuck key used and not left in the chuck of drilling machines?	2.08	0.515	133	2.06	0.533	135
(EC3)150	The small work piece held in a vice or clamp?	2.85	0.742	46	3.19	0.683	3
(EC3)151	Operators wearing fit clothing and gloves, etc.. While operating the machine?	2.71	0.706	60	2.83	0.712	62
(EC3)152	Grinding machines wheels adequately guarded?	2.63	0.699	71	2.78	0.697	70
(EC3)153	Precautions taken against flying fragments of disintegrated wheel?	2.47	0.597	88	2.47	0.641	84
(EC3)154	Grinding machines wheels fitted as per the designed speed and correctly fitted on the spring wheel?	2.67	0.679	64	2.92	0.740	51
(EC3)155	RPM clearly marked on the grinding machine?	2.99	0.708	16	3.06	0.735	36
(EC3)156	Grinding machines surrounding area kept neat and tidy and free of obstructions?	2.55	0.602	78	2.44	0.620	94
(EC3)157	Operators using PPE to protect against flying particles of grinding machines?	2.08	0.508	132	1.96	0.512	141
(EC3)158	Guard over the circular saw?	2.49	0.600	84	2.45	0.626	90
(EC3)159	Guard in place while working?	2.11	0.509	127	2.09	0.551	128
(EC3)160	Riving knife provided to prevent kick back?	2.98	0.678	20	3.13	0.727	12
(EC3)161	Area around the machine neat and tidy?	2.64	0.730	69	2.67	0.635	74
(EC3)162	Wood shavings, dust and chips regularly cleared?	2.5	0.598	83	2.40	0.631	105
(EC3)163	Good ventilation in wood working area?	2.14	0.527	120	2.13	0.564	123
(EC3)164	An operator using required PPE wile wood working?	2.47	0.600	89	2.41	0.622	102

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From the descriptive analysis conducted, the contractor respondents mean value was in the range of 1.74 to 3.21. From the view point of contractors the following top 10 factors have been identified as critical success factors: (1) Material handling; (2)Proper flooring for adequate load bearing capacity; (3) Ambulance room and emergency vehicles insuitable location; (4) Any arrangement with hospital for emergency treatment; (5) Power cables and welding cables protected from mechanical damage; (6) Material protected from weather and rain; and (7) Are the power tools provided with earth connection; (8) Insulations regularly inspected and records maintained; (9)Tool box talks regularly conducted and (10) Safety committee, indicate the most significant areas where Contractors respondents need to take into account when implementing safety management in their construction industry. Top Critical success factor on Contractors Perspective is shown in Table 2.

Table 2. Top Critical Success Factor on Contractors Perspective

Rank	ID	Factor	Mean	S.D
1	(EC1)49	Workmen trained in material handling?	3.21	0.705
2	(EC1)52	Proper flooring done with adequate load bearing capacity?	3.16	0.672
3	PS30	Ambulance room/ emergency vehicle suitable located?	3.15	0.699
4	PS16	Any arrangement with hospital for emergency treatment?	3.1	0.705
5	(EC2)107	Power cables and welding cables protected from mechanical damage?	3.08	0.677
6	(EC1)55	Material protected from weather and rain?	3.08	0.683
7	(EC3)135	Are the power tools provided with earth connection?	3.06	0.755
8	(EC1)91	Insulations regularly inspected and records maintained?	3.02	0.706
9	IS7	Employees given safety orientation?	3.01	0.672
10	IS6	Safety committee?	3.01	0.698

From the descriptive analysis conducted, the client respondents mean value was in the range of 1.81 to 3.32. From the view point of clients the following top 10 factors have been identified as critical success factors: (1) Fire Fighting training; (2) Temporary screens provided to protect others from welding rays, grinding sparks; (3) The small work piece held in a vice or clamp; (4) Power tools handled properly; (5) False work has been designed by a competent person; (6) Are the power tools provided with earth connection; and (7) Seat belts provided and are in use by the users; (8) Power cables and welding cables protected from mechanical damage; (9) Flame cutting and welding taking place with proper fire precautions and (10) Employees given specialized training where needed, indicate the most significant areas where client respondents need to take into account when implementing safety management in their construction industry. Top Critical success factor on Clients Perspective is shown in Table 3.

Table 3 Top Critical Success Factor on Clients Perspective

Rank	ID	Factor	Mean	S.D
1	(EC1)64	Trained persons to fight fire?	3.32	0.697
2	(EC2)110	Temporary screens provided to protect others from welding rays, grinding sparks?	3.2	0.681
3	(EC3)150	The small work piece held in a vice or clamp?	3.19	0.683
4	(EC3)136	Power tools handled properly?	3.19	0.727
5	(EC2)113	False work has been designed by a competent person?	3.19	0.729
6	(EC3)135	Are the power tools provided with earth connection?	3.18	0.671
7	(EC3)139	Seat belts provided and are in use by the users?	3.18	0.682
8	(EC2)107	Power cables and welding cables protected from mechanical damage?	3.18	0.72
9	(EC1)62	Flame cutting and welding taking place with proper fire precautions?	3.16	0.73
10	IS8	Employees given specialized training where needed?	3.14	0.676

V. CONCLUSIONS

Based on the response obtained from the contractor and client respondents through questionnaire survey, the following two factors are found to significantly influence the aspect of safety at construction sites:

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- Lack of knowledge about the necessary of earth connection for power tools.
- Lack of knowledge about cables protect from mechanical damages.

Furthermore importing safety awareness, training and conducting safety audit also help in ensuring safety at construction sites.

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