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Original

Investigating Satisfaction Levels of Safety Requirements in Mobile Cranes and its Relationship with Organization's Safety Culture

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Abstract

Background: disregarding safety requirements has made accidents of workshop mobile cranes as one of the main factors of injuries and death in civil-industrial projects. Since safety culture considered one of the most important activist indices while investigating the commitment of superior managers and other members of the organization to regard safety requirements, the present study aims at investigating the organization's safety culture in civil and industrial projects and its relationship with regarding safety requirements of mobile cranes. **Methods**: the current study is descriptive-analytical and cross-sectional research conducted within 7 civil-industrial projects from 2018 to 2019. To investigate satisfaction levels of safety requirements, 141cranes have been used through a 72-item researcher-made checklist adapted from ASME B30.5 2018 standard and protective regulation of transportation vehicles and moving materials and objects of workshops. The research team has confirmed the validity and reliability of the checklist with CVR=0.68, CVI=0.82, and Cronbach's alpha=α-0.90. To estimate safety culture levels 677 individuals of staff such as cranes operator, technician, expert, minor managers, middle managers, and superior managers have participated in this study through random sampling method, interview, and completion of safety culture questionnaire. To analyze data Kolmogorov-Smirnov tests, one way ANOVA and linear regression utilizing SPSS v25 have been employed (*P*-value < 0.05). **Results**: age average of study individuals equaled with 39.8 and average of their work experiences equaled with 12.29. Results out of this study revealed that there is a positive and meaningful relationship between organizations' safety culture and consideration levels of safety requirements in mobile cranes. So that parameter of management commitment (0.001), safety preference degree (0.004), staff training (0.012) and information exchange level (0.041) have the most relationship with consideration levels of safety requirements. But there was no meaningful relationship between work conditions and consideration levels of safety requirements (0.075). **conclusion**: based on results of this study it seems that accidents resultant from mobile cranes occur more in uncommitted organizations so it is important to develop organizations' safety culture through performance of academic interventions and inform organizations' staff especially superior management and consequently increase the safety factor of mobile cranes in civil-industrial projects.

Key words: Civil-industrial project; Mobile crane; Safety culture.

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Introduction

In developing countries industrialization issues, lack of proper management and attention to safety industrial principles have increased the rate of work accidents. Based on WHO's (World Health Organization) report 3.5 million individuals die because of work accidents and damages of these accidents estimated as 500 billion dollars.[1, 2] Civil-industrial activities have been located at the top of activities make accidents.[3, 4] Different studies have shown that most accidents and the most severe accidents after mine accidents are related to the construction industry in civil-industrial projects.[5] Statistics of the building industry showed that the rate of occurring accidents in civil-industrial projects is 50% more than in other industries.[6] Heinrich (1931) had theorized that unsafe activities (88%) are the main factor in happening accidents of work and only 10% of accidents are related to unsafe conditions. However, the reason for happing an unsafe condition is an unsafe activity.[7] Safety culture is considered one of the most important activist indices while investigating commitment levels of superior management and other organization's members to consider safety requirements and prevent unsafe activities.[8] The safety culture of an organization demonstrates the awareness level of that organization's staff of potential dangers within work conditions and how to predict and react to these dangers to omit or reduce risks of occurring accidents resultant from work conditions potential dangers.[9-11]

Consideration of national and international safety requirements by the organization's staff and not doing unsafe activities is one of the reductive factors of potential danger in civil-industrial projects.[12, 13] In previous studies, management introduced as the main element in safety culture.[14] Also, it seems that four factors such as 1- superior management's commitment to safety,[15] 2- common concern among other organization's staff about safety preference degree and their active cooperation in development of safety culture,[16] 3- constant training of staff and level of information exchange within OH&S field in organization[17] and 4- constant monitoring of work condition situations in organization[18] are influential of enhancing safety culture level and reducing accidents. Among occurred accidents, accidents related to mobile cranes due to high casualty and financial expenses and severity of resultant consequences have been turned to one of the health experts' challenges.[19] Therefore, consideration of safety requirements in cranes is a very important issue.[20]

To investigate safety level of measures related to loading by mobile cranes in Iran and safeguarding these measures, various regulations complied by Iran Labor Ministry such as protective regulation of transportation vehicles and moving materials and objects of workshops confirmed by Country Supreme Council of Technical Protection.[21] National regulations as well as international regulations used to safeguard work conditions in Iran. ASME B30.5 is one practical international reference in Iran related to the safety investigation of mobile cranes.[22] Respecting the importance of considering safety requirements in mobile cranes to prevent from occurrence of accidents resultant from work and the role of the human factor in commitment to satisfy these requirements, the present study aims at investigating satisfaction levels of safety requirements in mobile cranes and its relationship with organization's safety culture in Iran's civil-industrial projects.

Methods

This project has been conducted in seven civil-industrial projects including one heavy industry establishment project (m (Number of cranes)=29, n (Number of participants)=134), one power plant establishment project (m=26, n=118), one building construction project (m=14, n=79), three water transfer lines project (m=61, n=236) and one road construction project (m=11, n=28) during 2018 to 2019 in different cities of Iran.

Samples

To investigate satisfaction levels of safety requirements, 141 one cabin or two-cabin CTMC and WMC mobile cranes and RT-cranes from different producers included in this study. To estimate safety culture levels 752 individuals of staff such as cranes operator, technician, expert, minor managers, middle managers, and superior managers have been included in this study as participants. The inclusion criteria of cranes into this study are 1. Having at least one loading operations cycle within a day and those cranes that have been stood by more than one month before the study were not included in this study, 2. Having crane manual and 3. Having a specific certificate with code 41 for the

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crane operator.

Data Collecting Instruments

To investigate cranes, a 72-item researcher-made checklist including three options of Ok, Not Ok and NA[1] employed. This checklist adapted from ASME B30.5 2018[22] standard and protective regulation of transportation vehicles and moving materials and objects of workshops confirmed by Supreme Council of Technical Protection[21] and contains questions about crane track, crane operator, driver of track, status of crane jacks, operation cabin, hook, drum, boom, towing wire, crane reels, and loading operations. To standardize checklist, through the use of Expert Panel, corrective opinions of 20 specialists and experts in the safety of mobile cranes with inspection license from the center of health and technical protection training and researches and NACI in Iran have been employed. Commentators scored suitability of test' items based on their specialized opinion, validity coefficient of these questions determined based on this opinion polling according to table of validity coefficients for different tests. The study measured CVR=0.68 and CVI=0.82. After taking an average of this opinion polling, questions with unacceptable CVR modified or omitted. Cronbach's alpha used to measure the internal consistency and reliability of the questionnaire. It is important to mention that Cronbach's alpha is among the most common methods to determine reliability. Reliability is demonstrative of repeatability, stability and internal consistency of a questionnaire. To measure the questionnaire's reliability, the internal consistency method through the measurement of Cronbach's alpha (α-0.90) by means of SPSS v25 was used.

To investigate the safety culture of participants, a standardized safety culture questionnaire of Arghami and his colleagues (2010) was employed.[23] The questionnaire contains 65 questions and 5 parameters including management commitment, level of information transfer in the field of OH&S within the organization, staff training, the status of work condition and degree of safety preference in the organization. Reliability of the questionnaire confirmed by Cronbach's alpha coefficient which equaled 0.96.

Ethical Considerations

Samples included in this study by complete awareness of study purposes and completion of satisfaction letter. It was voluntary to take part in this study. Participants were promised that their information will remain confidential.

Procedure

Cranes investigated during two times. First time in the presence of crane operator when loading operation was not performed and the second time during the loading operation. To investigate technically, researchers presented at the point of crane location after coordination and investigated the consideration level of safety and technical requirements of the crane. After investigating each crane in every project, the safety culture of the organization's staff studied. To make sure that participants have understood questions of safety culture questionnaire, during a briefing session before the distribution of questionnaires, study purposes and how to answer them have been explained to the participants, questionnaires collected after completion by the participants by the research team. After collecting questionnaires only 677 ones were filled out and so they were evaluated.

Statistical Analysis

After collecting data related to the level of safety requirements of mobile cranes and the completion of the questionnaires, data analyzed by SPSS v25. After the representation of descriptive indices (average ± standard deviation, minimum, maximum and percent of variables) and normality of the data, data analyzed based on the purposes of the study. Kolmogorov-Smirnov test measured the normal distribution of data. To compare the average of consideration levels of safety requirements in cranes and level of organization's safety culture within 7 projects, one way ANOVA employed. To investigate the relationship between each parameter of safety culture and total score of safety culture and consideration levels of safety requirements, binary logistic regression test used. The purpose of this study is to measure the independent effects of each safety culture parameters (independent variable) on the total score of safety culture (dependent variable) and consideration levels of safety requirements in cranes (dependent variable) (P-value < 0.05).

Results

141 mobile cranes and 752 participants included during 7 projects that 677 of them have answered the questions correctly and completely. The age average of individuals was 39.8 with SD of 5.3 and work experience average was 12.29

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(3.14). The descriptive information of the participants is in tables 1 and 2. The maximum and minimum amounts of the organization's safety culture parameter and consideration levels of safety requirements in cranes are represented separately in table 3. Table 4 shows average and SD as well as findings related to the difference hypothesis of average for organization safety culture and consideration levels of safety requirements in cranes during projects. As a result of the table shows, the total score of safety culture in the power plant establishment project has the most amount (230.26). Also, it is observed that consideration levels of safety requirements in power plant establishment projects with the most average (64.09) have the most suitable status. Kolmogorov-Smirnov test confirmed a normal distribution of data (sig=0.02).

To investigate which one of safety culture parameters has the most effect on the final score of safety culture and consideration levels of safety requirements in cranes, binary logistic regression statistical test was employed and the results are summarized in Table 5. According to the table, parameters of management commitment (0.001), safety preference degree (0.004) staff training (0.012) and level of information transfer (0.041) have the most effect on the total score of safety culture and consideration levels of safety requirements in cranes, respectively. But there is no meaningful relationship between the status of work condition and consideration of safety requirements ($P > 0.05$).

Table 1. Descriptive information of the participants

Variable	Variable categorization	Standard deviation(average)
Age of individuals (year)	≤ 42 43-52 ≥53	4(40.33)
Work experiences (year)	1-10 11-20 21-37	3.14(12.29)

Table 2. Descriptive information of participants

variable	Variable categorization	Standard deviation (average)
Marital status	single	38.98%
	married	61.02%
Work row	Operator and co-operator of crane (rigger)	37.00%
	Technician (foreman, installation groups, formatting, reinforcement, impacting, structure installations, repairs, installations and …)	25.66%
	Expert (performance, technical office, support, machineries and …)	17.54%
	Middle and minor managers	12.57%
	Superior managers	1.92%
	Others	5.31%

Table 3. Maximum and minimum scores related to parameters of safety culture and consideration level of safety requirements in cranes during 7 projects

parameters / project	Management commitment	Level of information exchange	Staff training	Status of work condition	Degree of safety preference	Consideration level of safety requirement in mobile cranes
Establishment of heavy industries	46-131	19-61	22-57	19-32	13-25	49-68
Power plant industry	42-128	18-57	24-52	12-31	16-24	61.56-72
Building construction	46-119	22-59	19-53	11-26	8-19	39.17-59
project 1 water transfer	39-123	19-54	18-42	12-29	5-16	56.57-32.80
road construction	44-116	21-59	16-51	10-28	11-23	71-45.91
project 2 water transfer	37-97	22-57	21-44	8-24	7-15	56.74-34.97
project 3 water transfer	48-127	21-63	21-57	11-32	7-22	59.83-43.6

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Table 4. Comparing average of parameters of safety culture and consideration levels of safety requirements in cranes during 7 projects (statistical test of one way variance analysis or ANOVA)

parameters / project	Management commitment	Level of information exchange	Staff training	Status of work condition	Degree of safety preference	Total score	Consideration levels of safety requirement in mobile cranes
Establishment of heavy industries	117.34	30.87	28.16	22.48	21.89	220.74	62.55
Power plant establishment	118.78	27.61	38.59	27.24	22.04	230.26	64.09
Building construction	97.43	42.55	31.06	18.93	13.62	203.59	55.22
Project 1 water transfer	92.88	26.41	25.72	16.86	11.06	172.93	46.12
Road construction	94.15	32.11	34.59	18.21	16.78	199.84	47.86
Project 2 water transfer	76.66	38.43	29.04	12.81	10.27	167.21	44.27
Project 3 water transfer	112.38	39.77	28.07	14.76	12.49	207.47	53.29
P-value	*P*=0.005	*P*=0.018	*P*=0.029	*P*=0.047	*P*=0.011	*P*=0.002	*P*=0.001

$P < 0.05$

Table 5. Results of linear regression in relation with total score of safety culture and consideration level of safety requirements in cranes

Parameters of safety culture	Total score of safety culture			Consideration level of safety requirements in cranes		
	B	Wald	*P*-Value	B	Wald	*P*-Value
Management commitment	+1.613	12.957	0.005*	+0.991	8.113	0.001*
Level of information exchange	+0.701	4.203	0.040*	+0.541	4.195	0.05*
Staff training	+0.824	5.010	0.017*	+1.080	8.181	0.039*
Status of work condition	+0.589	4.002	0.038*	+0.258	2.011	0.063
Degree of safety performance	+0.901	7.440	0.009*	+1.200	9.981	0.011*

P<0.05*

Discussion

The present study aims at investigating the satisfaction level of safety requirements in mobile cranes and its relationship with safety culture parameters of organization in country civil-industrial projects. It is possible to investigate the performance of the organization's members in the field of consideration of safety requirements in projects through studying and investigating safety culture and to achieve a comprehensive understanding of the contribution of each workgroup in system safety.[24] Status of safety culture differs in different work conditions and civil-industrial projects have more complicated status than other procedural industries.[25] Many studies show that safety culture leads to the occurrence of sustainable safety in that condition.[26] So that Rahmati Najjar Kalaei showed that the performance of management and staff play an important role in the safety of the Gas Association of Southern Pars and it was recommended to provide equipment and safe occupational conditions to help staff do their duties safely.[27]

In contrast, the results of some studies are demonstrative of the minor role of safety culture in the occurrence of accidents. In this regard, it is possible to mention the study of Nouri and his colleagues (2012) observed no meaningful relationship between safety culture and unsafe behaviors among the staff of Iran refining and distributing oil products. This study showed that although safety culture is low among the staff, this factor may not lead to the incidence of unsafe behaviors.[28]

But results of the study show that there is a positive and meaningful relationship between total score of organization's safety culture and consideration levels of safety requirements in mobile workshop cranes and parameters of management commitment, degree of safety preference, staff training and level of information exchange have the most relationship with consideration levels of safety requirements. However, there is no meaningful relationship between the status of work conditions and consideration of safety requirements. On the other hand,

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parameters of safety culture have a meaningful and positive correlation with the total score of an organization's safety culture. Also, the parameter of management commitment observed as the main parameter which has the most effect on the level of the safety culture of the organization. It seems that the organization's superior management being able to able decisions has made safety principles as a public necessity when these principles are necessary and other members of the organization have to follow them. Arghami and his colleagues also showed that after safety management and crisis, interviewees mostly concentrate on management commitment and attitude. Interviewees maintained that attitude, commitment, and leadership of superior management of an organization is an important factor in the creation and stability of safety culture within an organization.[29] Shiney Chib (2014) in a study based on investigations of industrial accidents showed that safety culture is a considerable factor in the enhancement of safety requirements consideration in workshops. And this issue that organizations capable of a strong safety culture in preventing the incidence of accidents and industrial damages were more effective, has been confirmed. These results are completely consistent with this study's results.[30]

Ivar Havold (2010) in his study and also in his book published in 2018 in line with the present study's results showed that the attitude of superior management in the organization has a significant effect on safety guidelines.[31] Among parameters of this study, the second influential factor on an organization's safety culture is the degree of safety preference. In other words, when safety is capable of a higher preference degree that project progress, it will be impossible to perform mission without considering safety requirements and the organization will have to consider safety requirements for the advancement of the operational mission. It is impossible to perform a mission without considering safety requirements and the organization will have to consider safety requirements for the advancement of the operational mission. Among studied projects, safety preference has the highest degree in the project of power plant establishment. According to the mentioned studies and findings out of this study, it can be concluded that the establishment of safety culture in work conditions may lead to enhancement of safety requirements consideration in cranes and consequently significant reduction of related accidents. Mobility of cranes (types of tower, gate, and overhead cranes and …) are among limitations of this study concerning cranes inclusion criteria into this study. Other limitations include unreal answers of drivers to questions because of their mental and emotional status and undesired stress because of occupational problems.

Conclusion

The current study revealed that in organizations with the desired safety culture, each member obligated oneself to consider safety requirements of work conditions. This study determined that superior management has the most effect on consideration level of safety requirements of civil-industrial workshops among members of the organization. Since guidelines of advancing purposes based on a systematic framework of project control is mainly established by superior management. Therefore, the role of superior management in the guidance of organization members' thoughts concerning considering the safety requirements of work conditions is very important. On the other hand, organization's elements in civil-industrial projects in the positions of managers and experts of health and safety units, executive supervisors of technical offices of supporting affairs and machineries as disseminators of superior management guidelines in Occupational Safety and Health (OH&S) in large scale can develop and improve organization's safety culture through holding informing sessions, holding safety committees with presence of workers' agents, installation of posters and warning signs, monitoring awareness level of organization's members to safety regulations and constantly improving them. On the other hand, it should be considered that the creation of positive safety culture within organizations is a time-consuming process and may take years to be performed but the constant improvement of processes by reduction of accidents may lead to enhancement of the organization's productivity and its competitiveness.

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