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Identification and assessment of human errors among tower crane operators using SHERPA and CREAM techniques

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Abstract

Introduction: Cranes are of the major causes of accidents in the construction industries. As human error mostly causes crane accidents, this study aims to investigate the human errors of tower crane operators in the construction projects using SHERPA and CREAM techniques.

Material and Method: In this research, first, all of the tasks of the tower crane operator were identified and analyzed. Then, adopting SHERPA technique, probable operator errors were identified in each task and the control modes and error probability were determined by CREAM technique. Finally, all the human errors risks were assessed and the actions for risk control were defined to control them in the acceptable level.

Result: According to the SHERPA technique, 148 errors were identified in the crane operator tasks. The human error assessment showed that monitoring the anti-collision system with the risk probability of 0.0003 has the highest control factor, while monitoring the existing guards with the risk probability of 0.056 has the lowest control factor. Also, the important tasks with high human errors were monitoring the guards with the cognitive risk probability of 0.07 and the tasks with cognitive risk probability of 0.05.

Conclusion: The findings in this study indicated that using complementary qualitative and quantitative methods can provide identification and prioritization of identified errors. This can help the organization to allocate limited organizational resources to control unacceptable risks and increase the efficiency and effectiveness eventually.

Key words: Construction industry, Tower crane, Human error, SHERPA, CREAM

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1. Introduction

Fatal occupational accidents are frequently happened in the construction industries(1). Application of machineries and equipment is essential part of each construction project(2). Cranes are used in many kinds of construction project for lifting and transporting operations. It is important for any successful projects to use cranes safely and efficiently(3).Many studies have indicated that human errors resulted in accidents in the construction projects, for the safety of such projects depends on the individuals' performance(4). Investigation of the crane-related accidents has shown that human error is one of the most important factors causing the accidents; therefore, it is necessary to analyze the tower-crane operator's error in construction projects(5). The aim of this paper was to evaluate human error among tower crane operators in construction projects in Tehran city usingCREAM and SHERPA techniques.

2. Experimental

In this study, SHERPA and CREAM techniques were respectively used to identify human errors and quantitative risk assessment (6). The SHERPA method is composed of eight steps including: Hierarchical Task Analysis (HTA), task classification, Human Error Identification (HEI), consequence analysis, recovery analysis, ordinal probability analysis, critical analysis and remedy analysis(7, 8).The steps for evaluating human error in the CREAM method are as follows. The first step is to define the task and sub-task by HTA method. The second step is to determine control modes and common performance conditions (CPCs). Common performance conditions (CPCs) helps to determine human cognition and the context of actions. After calculating total CPCs scores, basic operator control modes are defined to evaluate human performance reliability. The final step is CFP which shows the probability of failure for each cognitive failure type.

3. Result and Discussion

HTA results showed eight major tasks and 27 sub-tasks for the tower-crane operator (Table 1). The results indicated that lifting operation involves the highest number of human error; the highest and lowest percent of human error were reported for *observing control lever* and *providing the operator with fall protection system,* respectively. According to figure1, 43% and 26% of total errors are related to operational and checking errors, respectively. According to the control mode of each sub-task, it has been shown that 13 sub-tasks involve strategic control mode(Table 2).The results of extended CREAM showed that, 16 risk cases related to observation error, 10 cases to execution error, one case to interpretation error, and one case to planning error. Based on the results, two cognitive sub-tasks (T.C.O.2.1 & T.C.O.8.4) are of crucial importance with high error probability; the CFPi of each of these two sub tasks (coordination & observation) is 0.07 and 0.05 respectively.

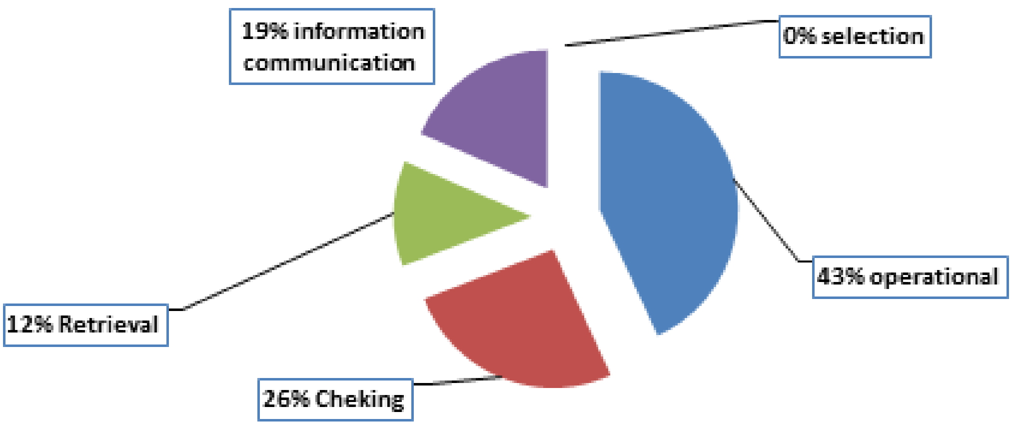

Fig. 1. Percentage of errors (according to the type of errors)

Table 1. Identification of tasks and sub-tasks of T.C.O

Major tasks	Sub-task
T.C.O.1. using fold-away fall arrest system	-
T.C.O.2. Controlling/checking the structure before operation	T.C.O.2.1. Controlling/checking guards
	T.C.O.2.2. Controlling/checking rails and stairs
	T.C.O.2.3. Controlling/checking joint sections
T.C.O.3. Mechanical controls	T.C.O.3.1. Controlling/checking crane hook safety latch with clamp, spring and bolt
	T.C.O.3.2. Controlling/checking tow rope for corrosion and abrasion
	T.C.O.3.3. Checking/inspecting dram and winch
T.C.O.4. Electrical controls	T.C.O.4.1. Controlling/checking electric panel
	T.C.O.4.2.Controlling/checking all the cables including the main one
	T.C.O.4.3. Controlling/checking the grounding cable
T.C.O.5. Performance control of safety system	T.C.O.5.1.Controlling/checking hook micro-switch and the spinning system
	T.C.O.5.2.Controlling/checking ACRS (anti-collision radio system) performance
	T.C.O.5.3. Controlling/checking emergency shutdown device (ESD)
T.C.O.6. Controlling lever checkups/ inspection	T.C.O.6.1.Controlling/checking hook lever
	T.C.O.6.2. Controlling/checking of Liver Charriot's performance
	T.C.O.6.3. Controlling/checking rotary lever
	T.C.O.6.4. Controlling/checking the brake and the clutch
T.C.O.7. Lifting process	T.C.O.7.1. Radio communication with safety unit to get information about the lifting process and weather condition
	T.C.O.7.2.Operator communication with rigger to be aware of obstacles in the process of lifting
	T.C.O.7.3. Operator communication with rigger to putCharriot Along the gravity center of the load
	T.C.O.7.4. Operator communication with rigger to ensure unobstructed space in the process of lifting
	T.C.O.7.5. Operator communication with rigger to control the load swing
	T.C.O.7.6. Operator communication with rigger to estimate the tonnage and type of load
	T.C.O.7.7. Reading the load chart to determine the Permissible loading capacity
T.C.O.8. Controlling/checking After operation	T.C.O.8.1. Raising the hook to the end
	T.C.O.8.2. Releasing the turn table system brake
	T.C.O.8.3. Turn the cabin power key off
	T.C.O.8.4. Informing the power unit to cut off the power supply

4. Conclusions

This study presents a framework for quantifying all the human risks involved in tower-crane-related operations. However, with the presented techniques it is only possible to identify the errors based on the related risks. Therefore, it is recommended that performance shaping factors (PSF) would be considered in risk analysis frame work in future studies. Finally, it should be mentioned that even though human error is found to be the main cause of crane accidents, one cannot ignore the faults existing in the design of the crane.

5. References

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Table 2. Final results of basic and extended CREAM technique

Basic CREAM					Extended CREAM				
Main tasks	**Sub-tasks**		**CFPt**	**Control mode**	**Cognitive activity**	**Cognitive function**	**Cognitive failure type**	**CFP_0**	**CFPi**
T.C.O.1.		0	0.0056	Tactical	Execute	Execution	E5	0.003	0.003
T.C.O.2.	T.C.O.2.1.	4	0.056	opportunistic	Co-Ordination	Observation	O2	0.007	0.07
	T.C.O.2.2.	3	0.0315	opportunistic	Diagnosis	Observation	O2	0.007	0.03936
	T.C.O.2.3.	0	0.0056	Tactical	Diagnosis	Observation	O2	0.007	0.007
T.C.O.3.	T.C.O.3.1.	-3	0.001	Strategic	Diagnosis	Observation	O2	0.007	0.00124
	T.C.O.3.2.	-4	0.0006	Strategic	Diagnosis	Observation	O2	0.007	0.0007
	T.C.O.3.3.	2	0.0177	opportunistic	Diagnosis	Observation	O2	0.007	0.0221
T.C.O.4.	T.C.O.4.1.	-2	0.0018	Tactical	Diagnosis	Observation	O2	0.007	0.00221
	T.C.O.4.2.	-3	0.001	Strategic	Diagnosis	Observation	O2	0.007	0.00124
	T.C.O.4.3.	0	0.0056	Tactical	Diagnosis	Observation	O2	0.007	0.007
T.C.O.5.	T.C.O.5.1.	-3	0.001	Strategic	Diagnosis	Observation	O2	0.007	0.00124
	T.C.O.5.2.	-5	0.0003	Strategic	Diagnosis	Observation	O2	0.007	0.00039
	T.C.O.5.3.	-2	0.0018	Tactical	Diagnosis	Observation	O2	0.007	0.00221
T.C.O.6.	T.C.O.6.1.	-3	0.001	Strategic	Diagnosis	Observation	O2	0.007	0.00124
	T.C.O.6.2.	-2	0.0018	Tactical	Diagnosis	Observation	O2	0.007	0.00221
	T.C.O.6.3.	-3	0.001	Strategic	Diagnosis	Observation	O2	0.007	0.00124
	T.C.O.6.4.	-4	0.0006	Strategic	Diagnosis	Observation	O2	0.007	0.0007
T.C.O.7.	T.C.O.7.1.	-2	0.0018	Tactical	Communication	Execution	E4	0.003	0.00094
	T.C.O.7.2.	-4	0.0006	Strategic	Communication	Execution	E4	0.003	0.0003
	T.C.O.7.3.	-3	0.001	Strategic	Communication	Execution	E4	0.003	0.00053
	T.C.O.7.4.	-2	0.0018	Tactical	Communication	Execution	E4	0.003	0.00094
	T.C.O.7.5.	-4	0.0006	Strategic	Communication	Execution	E4	0.003	0.0003
	T.C.O.7.6.	-4	0.0006	Strategic	Communication	Execution	E4	0.003	0.0003
	T.C.O.7.7.	-3	0.001	Strategic	Observation	Interpretation	I1	0.02	0.00002
T.C.O.8.	T.C.O.8.1.	0	0.0056	Tactical	Execute	Execution	E1	0.003	0.003
	T.C.O.8.2.	0	0.0056	Tactical	Execute	Execution	E5	0.003	0.003
	T.C.O.8.3.	2	0.0177	opportunistic	Execute	Execution	E5	0.003	0.00948
	T.C.O.8.4.	3	0.0315	Opportunistic	Co-Ordination	Planning	P2	0.01	0.05623

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