Assessing the Impact of Unmanned Aerial Systems on Project Site Safety and Accessibility: A Comprehensive Study

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ABSTRACT

The construction industry, responsible for shaping the modern world through iconic structures and critical infrastructure, faces a troubling challenge – a high frequency of occupational accidents. These accidents not only imperil workers' lives but also impose significant economic and environmental burdens. This paper delves into the multifaceted realm of construction site safety and risk management, with a particular focus on the risks associated with construction project monitoring. It explores existing literature, emphasizing the role of organizational management, worker involvement, safety systems, and cultural factors in fostering a safety-oriented environment. Additionally, it reviews studies from various countries, shedding light on diverse factors affecting construction site safety. Beyond human factors, the paper highlights risk inherent in construction projects, emphasizing the need for proactive risk management. The paper concludes by acknowledging the gravity of construction site accidents and their far-reaching consequences, underscoring the importance of holistic risk management strategies.

Keywords: Occupational accidents, Risk management, Construction project monitoring, Worker safety

INTRODUCTION

The construction industry is renowned for its pivotal role in shaping the modern world, with its creations ranging from iconic skyscrapers to critical infrastructure projects. However, this industry is also marred by a sobering reality – a disturbingly high rate of occupational accidents that endanger the lives of its workforce and impose substantial economic and environmental burdens. These accidents, which occur globally at an alarming frequency, demand comprehensive investigation and mitigation strategies.

This paper embarks on a journey to explore the multifaceted landscape of construction site safety and risk management. Specifically, our focus is on the risks associated with construction project monitoring, a critical aspect of ensuring both the well-being of workers and the successful completion of projects. We delve into the extensive body of literature dedicated to understanding the complex web of factors that contribute to construction accidents. As we navigate through this literature review, we discover the pivotal role of organizational management, worker involvement, safety systems, and cultural factors in fostering a safety-oriented environment within construction firms.

Moreover, we traverse the globe to examine diverse studies conducted in different countries, each shedding light on the unique challenges and factors affecting construction site safety. From Norway to Pakistan, China to the United States, these investigations have unearthed insights into worker and team dynamics, internal organizational structures, regulatory influences, and the importance of adequate training and supervision.

Beyond the human factors, we also explore a spectrum of risks inherent in construction projects, ranging from environmental protests to equipment failures, highlighting the need for proactive risk management

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strategies.

Furthermore, we dive deep into the harrowing statistics surrounding construction site accidents, recognizing the magnitude of this issue. Each accident is not just a statistic; it represents a human tragedy with far-reaching consequences for individuals, families, industries, and society as a whole. These accidents also exact a heavy toll on the financial health of the construction sector and have significant environmental implications.

In conclusion, this paper serves as a comprehensive foundation for understanding the critical dimensions of construction site safety and the associated risks in the context of project monitoring. By analyzing the existing literature, we aim to provide a valuable resource for researchers, practitioners, and policymakers who are dedicated to creating safer work environments and mitigating the devastating impact of accidents in the construction sector. Through a holistic understanding of these risks, we aspire to pave the way for safer, more efficient, and sustainable construction practices in the future.

RISKS ASSOCIATED WITH CONSTRUCTION PROJECT MONITORING

Numerous studies have investigated construction accidents, identifying key contributing factors. Aksorn and Hadikusumo (2008) underscored four crucial dimensions in safety plan management: worker involvement, safety prevention and control systems, safety arrangements, and management commitment. Bavafa et al. (2018) emphasized elements such as individual safety responsibilities, personnel selection, employee involvement, and safety evaluation in safety programs. Organizational management's role in safety management has been recognized as pivotal (Li et al., 2018), fostering a safety-oriented organizational culture (Asilian-Mahabadi et al., 2018). Efficient information and material management practices, along with technological tools, can promote a resilient safety culture and reduce construction project accidents (Feng and Trinh, 2019).

Studies conducted in various countries, including Norway (Winge et al., 2019), Pakistan (Memon et al., 2017), China (Chen et al., 2020), Hong Kong (Low et al., 2019), Mongolia (Usukhbayar and Choi, 2020), Malaysia (Yap and Lee, 2019), the United States (Al-Aubaidy et al., 2019), and Taiwan (Chen et al., 2020), have identified factors related to workers, work teams, internal company organization and management, safety regulations, workplace conditions, supervision, worker training, and individual responsibilities.

In addition to the mentioned factors, risks associated with construction works include protests from ecologists or the local population, poorly recognized soil structures like quicksand, poorly planned work schedules, equipment failures, employee absences due to illness or strikes, inadequate employee qualifications and performance, poor management of material resources, supplies, and personnel, delays in the timely supply of construction materials, poor quality construction materials, failure to maintain standards, insufficient control measures, expanding the scope of work beyond the original plan, and poor work organization.

Understanding and effectively addressing these risks are crucial for ensuring the successful and safe implementation of construction projects. Proactively managing these risks can help organizations mitigate potential accidents and create a safer working environment.

Construction Site Accidents

The construction industry witnesses a staggering number of fatal accidents annually, with approximately 60,000 reported cases worldwide. Shockingly, this equates to a worker losing their life due to an occupational accident every 10 minutes. The nature of the construction industry, marked by labor-intensive processes and high risks, contributes to this alarming statistic. Occupational accidents result not only in

human tragedies but also in significant financial losses for the sector on a large scale. Furthermore, these accidents have far-reaching implications for enterprise sustainability, considering the associated costs and environmental impacts. Industrial accidents, especially those of substantial magnitude, pose significant risks not only to public health but also to the environment (Takala, 1999; International Labour Office, 2004; Rubio, Martinez, Rubio &Ordoñez, 2008).

Construction operations rely on a diverse range of manufactured components, in addition to basic construction materials, and involve a substantial workforce exposed to challenging working conditions, hazardous materials, and machinery. The production process in construction carries various occupational accident risks, including falls from heights, equipment and machinery-related incidents, crane accidents, electric shocks, explosions, and fires. The welding process exposes workers to hazards like burrs, toxic fumes, and clouds of dust, leading to injuries or accidents resulting in lost working days (International Labour Office, 1992; Sorock, Smith & Goldoft, 1993; Everett & Frank, 1996; Tang, Lee & Wong, 1997; Ikpe, Felix & David, 2012).

To prioritize worker safety and minimize accidents in the construction sector, it is essential to comprehensively address these occupational risks. Implementing effective safety measures and providing appropriate training can contribute to creating a safer working environment and reducing the devastating impact of accidents in construction.

METHODOLOGY

In this study, a quantitative approach was chosen, utilizing a survey research method facilitated by a Likert Scale questionnaire (Baridam, 1995). The study encompasses registered professionals in construction-related fields in South-Eastern Nigeria, including Architects, Quantity Surveyors, Project Managers, Land Surveyors, Civil and Structural Engineers, Mechanical/Electrical Engineers, and Builders, all integral to Project Monitoring. The sample size of 408 was determined using the Taro Yamane formula, factoring in a 10% attrition rate. A Stratified Random Sampling technique was employed, ensuring proportionate representation from each professional group.

Primary data were collected through a questionnaire, distributed personally or via email and Google questionnaire. The questionnaire underwent validation by the research supervisor and a statistician to ensure reliability. To assess reliability, a pilot study was conducted using 20 questionnaires to test internal consistency through Cronbach's alpha. Data were analyzed using SPSS version 23, involving descriptive statistics (frequencies, percentages, means, and standard deviations) for data interpretation. Inferential statistics, specifically Factor Analysis (PCA) and Independent Samples t-test, were utilized for hypothesis testing. Sample size allocation was determined through proportionate representation, ensuring that each professional group had an appropriate number of participants in the sample.

DATA PRESENTATION AND ANALYSIS

Effects of Unmanned Aerial System on Project Site Accidents and Accessibility.

Table 1: Effects of Unmanned Aerial System on Project Site Accidents and Accessibility

S/N	Factors	Very low n (%)	Low n(%)	Moderate n (%)	High n(%)	Very high n (%)	Mean ± SD
1	Accident on transit	77 (19.5)	205 (51.9)	0 (0.0)	101 (25.6)	12 (3.0)	2.41 ± 1.15

2	Falling debris, materials, or objects	61 (15.4)	185(46.8)	8 (2.0)	121(30.6)	20 (5.1)	2.63 ± 1.21
3	Natural disaster	113(28.6)	188 (47.6)	4 (1.0)	86 (21.8)	4 (1.0)	2.19 ± 1.11
4	Falls from high heights or scaffolding	77 (19.5)	198 (50.1)	0 (0.0)	112 (28.4)	8 (2.0)	2.43 ± 1.15
5	Demolition Accidents	90 (22.8)	200 (50.6)	12 (3.0)	89 (22.5)	4 (1.0)	2.28 ± 1.08
6	Trip and Falls/ Slip and Falls	78 (19.7)	224 (56.7)	0 (0.0)	81 (20.5)	12 (3.0)	2.30 ± 1.09
7	Fires & Explosions	109(27.6)	198 (50.1)	4 (1.0)	76 (19.2)	8 (2.0)	2.18 ± 1.09
8	Crane & Forklift Accidents	85 (21.5)	202 (51.1)	8 (2.0)	88 (22.3)	12 (3.0)	2.34 ± 1.13
9	Repetitive stress injuries	85 (21.5)	196 (49.6)	4 (1.0)	102 (25.8)	8 (2.0)	2.37 ± 1.14
10	Trench accidents	77 (19.5)	218 (55.2)	12 (3.0)	84 (21.3)	4 (1.0)	2.29 ± 1.04
11	Machinery accidents	89 (22.5)	200 (50.6)	8 (2.0)	86 (21.8)	12 (3.0)	2.32 ± 1.14
12	Exposure to dangerous chemicals or toxins	89 (22.5)	193 (48.9)	8 (2.0)	88 (22.3)	17 (4.3)	2.37 ± 1.18
13	Harmful materials	73 (18.5)	214 (54.2)	8 (2.0)	88 (22.3)	12 (3.0)	2.37 ± 1.11

Table 1 shows low effect of an unmanned area system on risk/accidents involved in construction project monitoring. This is indicated by mean response values less than the criterion mean of 3. They include Accident on transit (2.41 ± 1.15), Falling debris, materials, or objects (2.63 ± 1.21), Natural disaster (2.19 ± 1.11), Falls from high heights or scaffolding (2.43 ± 1.15), Demolition Accidents (2.28 ± 1.08), Trip and Falls/ Slip and Falls (2.30 ± 1.09), Fires & Explosions (2.18 ± 1.09), Crane & Forklift Accidents (2.34 ± 1.13), Repetitive stress injuries (2.37 ± 1.14), Trench accidents (2.29±1.04), Machinery accidents (2.32±1.14), Exposure to dangerous chemicals or toxins (2.37 ± 1.18) and Harmful materials (2.37 ± 1.11).

Hypothesis Testing

H_O: The use of unmanned aerial system (UAS) has no significant impact on reducing project accident and improving accessibility in construction project sites.

Table 2: Comparison of the Impact of UAS and On-site monitoring on reducing project accident and improving accessibility in construction project

Project monitoring				
	Use of UAS	On site	t	P value
Reduces Project accident and improves accessibility	3.29 ±0.71	2.35±0.79	3.188	0.002

Decision rule:

Since the significant value (p = 0.002) of the t statistic is less than 0.05 level of significance, the null

hypothesis is hereby rejected and the alternative accepted. Therefore, the use of unmanned aerial system (UAS) has a significant impact on reducing project accident and improving accessibility in construction project sites.

The mean response score of 3.29 for UAS is significantly higher than that of the On- site (2.35).

FINDINGS

The research findings reveal a limited effect of Unmanned Aerial Systems (UAS) on risk and accidents in construction project monitoring. The study examined the impact of UAS implementation on various risk factors and accidents commonly associated with construction projects. The mean response values for these factors were below the criterion mean of 3, indicating a low impact of UAS in mitigating these risks.

The study identified specific risk factors and accidents where the effect of UAS on construction project monitoring is relatively low. These include accidents during transit, falling debris or objects, natural disasters, falls from heights or scaffolding, demolition accidents, trip and falls or slip and falls, fires and explosions, crane and forklift accidents, repetitive stress injuries, trench accidents, machinery accidents, exposure to dangerous chemicals or toxins, and harmful materials. UAS implementation was found to have limited effectiveness in addressing and mitigating these specific risks.

CONCLUSION

The research findings reveal the limitations of UAV technology in directly mitigating risks and accidents in construction project monitoring. While UAVs can provide valuable data and insights, additional measures and safety protocols are necessary to effectively manage and mitigate specific risks. It is crucial for construction stakeholders to implement comprehensive safety strategies that combine UAV technology with other risk management practices to ensure worker safety and mitigate potential accidents and hazards on construction sites.

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