Available online at
http://journal.uitm.edu.my/ojs/index.php/BEJ

e-ISSN: 2637-0395

Built Environment Journal 22 (1) 2025, 1 – 13.

Built Environment Journal

Exploring the Utilisation of Drone Technology in Construction: Insights and Practices Within the Sarawak Region

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ARTICLE INFO

Article history:
Received 6 March 2024
Revised 7 June 2024
Accepted 11 June 2024
Online first
Published 1 January 2024

Keywords:
Drone technology
Unmanned Aerial Vehicle (UAV)
Construction technology
Construction stages
Aerial inspection

DOI:
10.24191/bej.v22i1.977

ABSTRACT

This study evaluates the application of drone technology in the construction industry, particularly in the Sarawak vicinity. Using a quantitative methodology, data were collected via a survey targeting construction professionals. The findings indicate that a majority of respondents are familiar with drone technology, with engineers being the primary users. Drones are utilised across various construction stages for tasks such as monitoring and inspection, preventing project delays, mapping, and compliance with safety regulations. The study also highlights several challenges, including weather limitations, battery life, security concerns, and operational complexity. Despite these challenges, drones offer significant advantages such as ease of control, immediate inspection capabilities, high-quality data collection, and enhanced worker safety. 74% of respondents acknowledged the ease of drone deployment, 80% noted their flexibility, 92% appreciated their ability to capture high-quality images, and 86% valued remote site access. The research concludes that while drone technology is recognised and utilised in the construction industry, further efforts are needed to promote its broader adoption through training and budget allocation for drone management.

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https://doi.org/10.24191/bej.v21i1.977

INTRODUCTION

Drone technology, renowned for its capacity to operate unmanned aircraft or Unmanned Aerial Vehicles (UAVs), has traditionally been associated mainly with military purposes. However, recent years have witnessed a significant expansion of drone applications into commercial and non-commercial domains worldwide. Drones are now widely utilised for tasks such as aerial photography, surveillance, digital communications, and community rescue operations, with the ability to gather ultra-high-resolution data from remote locations like mountain peaks, coastlines, and islands (Xu et al., 2017; Alsamarraie et al., 2021; Choi et al., 2023).

In the construction sector, drones play a pivotal role across all project stages, including land management, logistics, on-site construction, maintenance, and demolition (Norhayati et al., 2021; Sanson, 2019). This study primarily examines their usage for monitoring construction progress. Advancements in UAV technology offer numerous advantages, notably ease of control and deployment (Ayema, 2021; Sanson 2019; Mary 2022). With evolving drone-control technology, even operators with limited technical expertise can swiftly deploy and operate drones. Compared to crewed aircraft, UAVs offer greater manoeuvrability, lower flight altitudes, and enhanced navigational capabilities, enabling immediate inspections and adaptable task performance, including high or low altitude inspections, catering to diverse client needs (Aziz, 2016). The construction industry, particularly building developers, recognises the benefits of drones for tasks such as rooftop inspections, capturing high-quality photos and films, and thermal imaging (Yoo, 2021). Leveraging advanced drone technology facilitates more efficient project delivery by enabling real-time tracking of construction progress, thus mitigating delays and operational challenges commonly encountered with traditional monitoring methods. Drone footage provides comprehensive and timely data, offering superior visibility compared to conventional monitoring approaches reliant on written reports and eye-level photos, thereby saving time and enhancing efficiency (Yan Li & Chunlu Liu, 2019).

Legal considerations in Malaysia classify drones as civil or government aircraft, subject to stringent performance standards and mandatory flight permissions. Commercial drones exceeding 20 kg require a civilian pilot's license, necessitating authorisation from relevant government ministries before operation (Noor, 2018). Adhering to regulatory frameworks ensures lawful drone usage in construction applications. Furthermore, data collected by drones can be analysed using various techniques such as image processing and computer vision to extract valuable insights for decision-making. These analyses facilitate progress monitoring, surveying, safety inspections, quality monitoring, and activity analysis during construction, expediting condition evaluations of existing infrastructure systems (Hatoum & Nassereddine, 2022).

This paper emphasises the application of drones in the construction industry, drawing on suitable literature and immersive technology studies to analyse their implementation. By adhering to legal requirements and leveraging advanced data analysis techniques, drones offer unparalleled potential to enhance construction practices and project outcomes. With vast integration of drone technology into the construction industry has revolutionised traditional practices, offering unprecedented efficiency, accuracy, and safety improvements. However, to align with the specific focus of this study on the Sarawak region, it is crucial to contextualise these advancements within the local landscape. Sarawak, with its unique geographical and infrastructural challenges, presents a compelling case for the utilisation of drones in construction. In Sarawak, drone technology has been employed in various construction projects to address specific regional needs. For instance, the use of drones in the construction of the Pan Borneo Highway has been instrumental in surveying large areas of difficult terrain, providing real-time data, and ensuring precise planning and execution. Similarly, drones have been used in the development of remote rural areas, where traditional surveying methods are often impractical due to accessibility issues. By incorporating these

https://doi.org/10.24191/bej.v21i1.977

regional specifics and examples, this paper aims to provide a detailed and relevant analysis of drone technology implementation in Sarawak's construction industry

Main Application of Drone in the Construction Industry

Fig. 1: Drone in Construction Industry

Source: Author 2024

(i) Monitoring and Inspection - Regulations oversee the safety of construction workers, preserve the environment, and assure the building's safety and beauty. Although the government considers regulation to be vital, "regulatory requirements and limits have become a potential minefield that exposes owners to responsibility" (Sharma, 2019). Compliance with rules may be both expensive and time-intensive. Drones provide a low-cost and speedy answer to this problem (O Catterall, 2019)

(ii) Preventing Project Delays - Drones with aerial photography and video recording capabilities can give bare-bones real-time documentation, allowing owners and contractors to change work schedules. Drones flew around the building site (once a week) and collected data, which management used to monitor how the project was moving and automatically highlighted work that were behind schedule. The initiative has been judged effective, and it also gives managers and owners the option to directly monitor worker productivity (Cardil et. al., 2019).

(iii) Mapping - Drones can readily visit difficult-to-reach regions, minimising the likelihood of a land surveyor meeting hasardous circumstances. Mapping with a drone will shorten some steps of manufacturing. Similarly, another construction business employed drones to create 3D topography models, reducing the time required surveying a property by 98% (Xu et. al., 2020).

(iv) Construction Regulations of The Occupational Health and Safety Administration - OSHA may use drones to investigate incidents. It would save time and resources by deploying a drone to collect images and videos of all areas of the workplace (Yildiz et. al., 2021). OSHA officials are sometimes stumped as to who is to blame for a violation. Assume there is a multi-story structure with all concrete decks floored, but no walls. Someone shifts, and a guy falls to his death because of the absence of the barricade. It would be difficult to tell who moved the barricade, and it is possible that a drone may assist in allocating or determining culpability. In

https://doi.org/10.24191/bej.v21i1.977

certain cases, OSHA may be able to identify blame by reviewing successive daily images of a workplace.

(v) Evidence - Construction defect lawsuits are one of the most common types of construction litigation. These can occur in a variety of circumstances, but they usually include a negligent person. A contractor, for example, may be held liable if he fails to fulfil designs and specifications. The words that follow are examples of how drones could be used to prevent construction fault claims before the job is too far advanced to be repaired. Drone thermal energy technology might detect the presence of moving clay, alerting builders (Danielak, 2018) Figure 1.

Challenges of Implementing Drone Technology in the Construction Industry

(i) Damage and Bad Weather are Potential Threats - In harsh weather, drones have significant limits. They are unsuitable for usage at high temperatures, such as those seen on construction sites (He et al., 2017). Drone flight control might be difficult in sub-zero conditions. In cold temperatures, a battery normally does not perform as well. According to Grind Drone (2017), drones are dangerous to wild animals when they fly into densely populated regions with wild animals, which is typically classified a beast. Hawks and other large flying animals attack and capture Unmanned Aerial Vehicles (UAVs) because they often attack them while soaring through the sky and collecting critical images or movies

(ii) Limitation of Drone Battery Life - Drones have a shorter service life. Although the drone is highly convenient, the camera used to record photographs or movies is significantly shorter than that of a standard camera. Most drones have at least 4 hours of battery life since the battery is less developed and cannot survive more than 4 hours to undertake intense activities (Grind Drone, 2017).

(iii) Security Concerns - There is a greater risk of sensitive information being compromised when drones collect precise data on utility infrastructure (Labovich, 2017). This safety problem needs the use of a security system to provide effective assault defence. Many of the data acquired by drones is sent to the cloud through Wi-Fi or Bluetooth, making the drone more vulnerable to hackers. As a result, drones are vulnerable to cyber-attacks. Hackers might take advantage of the drone's lack of protection to gather important data (Yamani et. al., 2021).

(iv) Safety Issues - Human error, signal loss between the drone and the operator, and technological faults can all result in genuine public safety hazards, such as drones falling from great heights and colliding with people. The hazards that workers face as a result of working with drones. The hazards connected with flying a drone need the use of additional security measures to prevent mishaps. Furthermore, Srewil (2016) emphasised that workplace safety is a top priority, particularly when it comes to issues like distractions and even drones (Dukowitz, 2020).

(v) Complexity - When utilising a hot camera under an unmanned aircraft, the camera operator knows exactly what to focus on. Although the drone may fly without human interaction, if Global Positioning System (GPS) is lost, the remote controller must be utilised (Janssen, 2015). The more difficult is to monitor building progress and have construction work accepted while attempting to arrange a flight mission using a drone. It is varied because it must integrate and represent many sources of information.

https://doi.org/10.24191/bej.v21i1.977

METHODOLOGY

A quantitative methodology involved both primary and secondary data collecting. By analysing their thoughts on the employment of drone technology in the construction project. Respondents were chosen through targeted sampling based on their experience and knowledge of drone applications in Sarawak, Malaysia. Managers of drone manufacturing firms that supply drone services, as well as contractors who use drones on construction sites, were the intended respondents. Although the sample size was small because the majority of the invited prospective responders declined to participate, this strategy yielded very rich data. The primary data was gathered via an online poll, while the secondary data was gathered from databases available on the Federal Aviation Administration's (FAA) website to enhance the analysis of drone technology implementation in the construction industry. Specifically, the UAS (Unmanned Aircraft Systems) Registrations Database, the Airspace Authorization Database, and the Drone Safety Reports Database. From these, data on drone registrations, focusing on types and specifications commonly used in construction, as well as airspace authorisations that detailed the scope and nature of drone operations were extracted. A Google Forms-based online survey questionnaire was created and delivered to many persons working in the construction site particularly in Kuching, Miri, Mukah and Sibu, Sarawak. To protect respondents' anonymity, the poll did not include their names, or the names of companies linked with their survey responses. The analysis employed quantitative methods to analyse respondents' thoughts on drone technology in construction projects, including demographic background, potential users, scope of works, and advantages and disadvantages to ensure readers understand the comprehensive approach taken during the research process.

RESULTS & ANALYSIS

Respondents' Demographic Background

The findings in Table 1 showed that 48% of respondents are main contractors, followed by sub-contractor (20%), consultant (10%), developer (12%), public sector (6%), client and power utility (2%) respectively. As observed, the majority of the respondents are from medium and large construction companies. In this study, medium construction companies refer to firms that undertake projects of moderate scale and may have a moderate workforce and revenue compared to smaller counterparts. On the other hand, large construction companies generally denote firms engaged in large-scale projects with significant resources, extensive workforce, and substantial revenue. Main contractors may focus on overall project management and efficiency, while sub-contractors may prioritise specific tasks and coordination with other stakeholders. Public sector representatives, on the other hand, may emphasise regulatory compliance and public safety.

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https://doi.org/10.24191/bej.v21i1.977

Table 1. Type of Organisation

Demographic Variable	Organisation	Frequency	Percentage (%)
Type of Organisation	Main Contractor	24	48
	Sub-contractor	10	20
	Consultant	5	10
	Developer	6	12
	Public Sector	3	6
	Client	1	2
	Power Utility	1	2

Source: Authors (2024)

Users of Drone Technology

Table 2 shows that engineers are the biggest users of drone technology in construction company with 68%. The engineers might be from the organisation itself or from consultant firms hired by the contractor. For example, the consultant firm with resources on drone technology could be hired to provide expert advice on the drone deployments. More than half, 46% of the responses agreed that contractors are the potential users of the drone in the construction for project monitoring purposes, thus avoiding project delays. 22% of respondents agreed that other stakeholders are potentially responsible for deploying the drone in capturing high-quality photographs and reports to clients. Further 4% agreed that supervisors are the potential users, since their job scope is often in the field to oversee overall work progress at the site area.

Table 2. Users of Drone Technology

No	Users	Frequency	Percentage (%)
1	Engineer	34	68
2	Contractors	23	46
3	Other stakeholders	11	22
4	Supervisor	2	4

Source: Authors (2024)

Scope of Works Required Drone Technology

Pre-Construction Stage

It is revealed in Table 3 that the responses within the scope of works during pre-construction stage is in a close range of percentage distribution. Foremost, over 88% of respondents agreed with the usage of drone technology to check existing utilities at the site during the pre-construction stage, comprising the source of water, gas, electricity, sewage system, communication services etc. According to Entrop &

Vasenev (2017), drones are becoming widely used by utility operators due to their altitude and flying distance, as well as their components equipped with advanced sensors and imaging technology to check various scale of utility construction projects. The second scope of work is deploying drone for site survey is similarly percentage with the previous statement, in which 88% of agreement. Fundamentally, drone is used for surveying or monitoring works with the aid of aerial photography to fly over the site area or property area (Davis, 2021; Winters & Sobola, 2021). This may benefit land surveyors to complete their site survey work instead of manually working at hasardous locations with steep terrain or near to heavy machinery (Elghaish; 2020). The procedure of the site survey is recognised as the drone-based photogrammetric that involve survey using photographs to create accurate maps or measurements of objects and surfaces, providing instant data to the user. Followed by the ability of drone to spot possible issues then outlining solutions during pre-construction phase that represented by 70% respondents agreed with the assertion. Using site management as an example, virtual sceneries at the site are developed using Augmented Reality (AR) the technology that overlays digital information or virtual objects onto the real world to help contractors or managers identified the issues then made necessary revisions for a success project performance. In order to prepare cost estimating for the project during pre-construction stage, 78% of respondents opined that drone technology is necessary. In addition to evaluate structural member measurements for decision-making of cost-estimating for the project, the three-dimensional (3D) data generated from the drone can be a useful tool for cost management in terms of tracking the amount of materials entering and leaving the construction site.

During Construction Stage

Findings also revealed that there are numerous of construction-related scopes of work required the application of drone technology. A total of 78% of respondents indicated that they would use drone mostly for site clearing and demolition work during construction process. Drone thermal imaging and simulation feature of the drone might foretell how a building will collapse, enabling to provide a safe demolition environment. About half of the responses opined the drone technology is implemented for excavation tasks. As mentioned by Patel et al., (2021), it is known as deep-excavation digital construction technology, and the multirotor drone controlled by a smartphone is used to collect support system geometry while excavation is taking place and convert it from two-dimensional (2D) imaging data into 3D models. A small percentage of 40% respondents selected concreting work as one of the scope of tasks that required drone technology by assessing the quality of concrete pours in accordance with the standards or requirements of concreting work. Ultimately, over 86% of respondents agreed that drone is used to inspect progress works on a daily, weekly and monthly basis throughout the construction process. The capability of drone to gather accurate and timely data that can be directly transferred into reports without the need for manual reporting has demonstrated that the construction sector has widely applied this advanced technology for works execution at the construction site (Gayatri Mahajan, 2021; Patel et al., 2021; Yi & Sutrisna, 2020; Kangude et al., 2021).

https://doi.org/10.24191/bej.v21i1.977

Table 3. Scope of Works Required Drone Technology

No.	Pre-construction Stage	Frequency	Percentage (%)
1	Checking existing utilities at the site area	44	88
2	Site survey	44	88
3	Identify potential issues then outlining solutions	35	70
4	Prepare cost estimating of the project	39	78
No.	**During Construction Stage**		
1	Demolition and site clearance	39	78
2	Excavation work	25	50
3	Concreting work	20	40
4	Inspection on daily, weekly and monthly progress works	43	86
No.	**Post-construction Stage**		
1	Final inspection and walkthrough of the project	49	98
2	Carrying out testing work on the mechanical and electrical (M&E) installations	8	16
3	Identifying construction defects	31	62
4	Identifying architectural errors	36	72

Source: Author, 2024

Post-construction Stage

According to the data gathered from the distribution of the questionnaires, final inspection and walkthrough of the project impeded the highest percentage of 98% among all scope of works of different stages. Once the construction works are completed, the drone equipped with a camera from the ground is required to inspect the overall satisfaction of the project. The project's final walkthrough could include either high-altitude or low-altitude inspections, demonstrating the flexibility of the drone capable of providing high-resolution data at a low cost (Xu Gao, 2017). In contrast, a small percentage only 16% of respondents agreed on the requirement of drone to conduct testing work for Mechanical and Electrical (M&E) installations. It is proven that inspection with one's own eyes remain relevant because M&E components required detailed and precise inspection to ensure smooth operation. Nevertheless, there is also drone equipped with Forward Looking Infrared (FLIR) that capable to detect heat in faulty electrical joints and insulation defects (Vergouw, 2016). In addition, 62% respondents chose the option of the drone requirement to identify construction defects at the post-construction stage. By referring to the study done by Maghazel & Netland (2020) on the development of crack detection system with UAV and digital image, this part of response determined that the capability of drone is beyond detection of cracks but managed to calculate quantitative crack width image analysis technique. The implementation drone for architectural work is used not just specifically for the design development but also used for identifying architectural errors, with more than half of the 72% respondents agreed on the statement. The representation of 3D model from the drone is principally in accordance with the architecture's vision, therefore any visible errors can be identified right away.

https://doi.org/10.24191/bej.v21i1.977

Advantages and Disadvantages of Drone in Construction Industry

It is shown from Table 4, 74% of respondents believed that the ability of drone to control and deploy its operations to fly for a variety of applications is advantageous. Because of its adaptability to high and low altitudes, more than half of the responses, 80% agreed that immediate inspection work could be done. A large percentage, 92% of respondents agreed that the drone can perform variety of tasks, including the capture of high-quality photos, aerial films and thermal images. Besides that, 36% agreed on the benefit of drone to improve worker safety to reduce accidents at site. Respondents also opined for over 86% that remote access to the current state of construction site give the construction organisation an advantage when deploying drone technology. 44% of respondents opined on the disadvantage in software or drone technology malfunction. More than half of the respondents, 72% believed that security concerns that could be risk to public' privacy. The highest percentage of 82% respondents agreed that drone is vulnerable to bad weather, which can result in incorrect or inaccurate images. Aside from that, more than 80% agreed on the drone's limitation of only being able to operate in certain areas. 86% of responses comprised that construction workers needed basic knowledge and skills to operate the drone.

Table 4. Advantages and Disadvantages of Drone in Construction Industry

No.	Advantages of Drone in Construction Industry	Frequency	Percentage (%)
1	Easy to control and deploy its operations to fly for a variety of applications	37	74
2	Immediate inspection works can be done due to its flexibility towards high and low altitude	40	80
3	Able to perform variety of tasks, including the capture of high-quality photos, aerial films and thermal images	46	92
4	Improve safety of workers to reduce accidents at site	18	36
5	Remote access to the current condition of construction site	43	86

No.	Disadvantages of Drone in Construction Industry	Frequency	Percentage (%)
1	Issues of software or malfunction of drone technology	22	44
2	Security concerns that may be risk to public' privacy	36	72
3	Bad weather issues may result to wrong or inaccurate images	41	82
4	Certain areas are not allowing the operation of drone	40	80
5	Requires basic knowledge and skills to operate the drone	35	70

Source: Author, 2024

Conclusion

This study has made a significant contribution to understanding the implementation of drone technology in the construction industry as a whole and Sarawak vicinity in particular. Through comprehensive survey questionnaires, we have identified the extensive adoption and familiarity with drone technology among industry professionals. The responses indicate a broad acknowledgment of this advanced technology and highlight the need for responsible operation to prevent potential public inconvenience.

Drone implementation in construction projects has been analysed across different stages, from planning and design to pre-construction, construction, and post-construction. Respondents also provided insights into the effectiveness of drones across various attributes and maintenance strategies. The study's findings on the major purposes, opportunities, and obstacles associated with drone use provide a robust foundation for further research and practical application. Open-ended questions enriched the data with respondents' personal opinions, ensuring a comprehensive understanding of the topic.

https://doi.org/10.24191/bej.v21i1.977

The research objectives have been successfully met, with all data collection satisfying the requirements. However, despite the rich data yielded, further efforts are needed to promote the widespread application of drone technology. This includes offering more training, workshops, and roadshows to educate potential users across the organisation, rather than relying on a single responsible party.

To facilitate this, construction organisations should consider providing royalty-free drone licenses to eligible workers, as proper licensing should not be a barrier to use. Given the high purchase and maintenance costs of drones, developers, clients, and authorities should allocate specific budgets for drone management in tender documents to ensure that this technology can be implemented without burdening contractors. Encouragement to adopt drone technology should be propagated throughout the construction industry, ensuring its benefits are fully realised.

ACKNOWLEDGEMENT

The authors would like to thank everybody who contributed to answer the questionnaires survey. The project would not have been successful without their cooperation and input.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS ' CONTRIBUTION

Mohamad Nidzam Rahmat designed the study, Ervina Donnis performed the surveying work, process the questionnaires data, analyse the results and writing the manuscript. Nidzam reviewed the results and approved the final version of the manuscript.

REFERENCES

Ayema D (2021). Utilizing drone technology in construction industry. Construction Review https://constructionreviewonline.com/machinery-equipment/drones-in-construction/

Aziz, A., Rahman, A., Shafrina, W., Mohd, W., Nizam, K., Maulud, A., Mohd, N., Mohan, M., Cardil, A., Silva, C. A., Norasma, N., Ya, C., & Naba, N. I. (n.d.). Applications of Drones in Emerging Economies: A case study of Malaysia.

Cardil M, Silva A, Norasma C A, Ya C, & Naba N. I. (2019). The Benefits and Risks of Using Drone in Construction. https://www.labewarranty.com.co.uk, 2019.

Danielak, M. (2018). The Benefits of Employing Drones in Construction. https://www.constructiondive.com/news/the-benefits-of-employing-drones-in construction/516713 Engineering, SSP - Journal of Civil Engineering, Vol 14 Issue 1. https://sciendo.com/article/10.1515/sspjce-2019-0003

Davis A. (2021). Introducing drones into construction for topographic surveys. Available: https://highways.today/2021/03/23/drones-topographic-surveys, 2021.

Dukowitz Z. (2020). Drones in construction: How drones are helping construction companies save money, improve safety conditions, and keep customers happy: https://uavcoach.com/drones-in-construction/.

Elghaish F. (2020). Towards digitalization in the construction Industry with immersive and drone technologies: A critical Review: Smart and sustainable built environment: https://emetald.com, 2020.

Entrop, A. G., & Vasenev, A. (2017). Infrared drones in the construction industry: Designing a protocol for building thermography procedures. Energy Procedia, 132, 63–68. https://doi.org/10.1016/j.egypro.2017.09.636

Gao, M., Xu, X., Klinger, Y., Van Der Woerd, J., & Tapponnier, P. (2017). High-resolution mapping based on an Unmanned Aerial Vehicle (UAV) to capture paleoseismic offsets along the Altyn-Tagh fault, China. Scientific Reports, 7(1), 1–11. https://doi.org/10.1038/s41598-017-08119-2

Grind Drone (2017), Advantages and Disadvantages of Drone Technology. Retrieved on April 30, 2018 from http://grinddrone.com/drone-features/advantages-and-disadvantages-drone

Hatoum M. B, & Nassereddine H. (2022). The Use of Drones in the Construction Industry: Applications and Implementation. Proceeding of the International Symposium on Automation and Robotics in Construction. Vol 39 pp 254-259

Hee-Wook Choi, Hyung-Jin Kim, Sung-Keun Kim and Wongi S. Na (2023), An Overview of Drone Applications in the Construction Industry. Drone 2023. 7, 515. https://doi.org/10.3390/drones7080515

Janssen, S. L. (2015). Assessing the perception of drones in the construction industry. University of Twente. Bachelor Thesis. Retrieved on March 7, 2018, from http://essay.utwente.nl/68985/1/Janssen-Simon.pdf

Joseph S.Sanson (2019). Drone use in the construction industry leads to integration into the current civil and construction engineering technology curriculum. Proceeding of the 2019 conference American Society for engineering education. https://216.185.13.131/drone-use-in-the-construction-industry-

leads-to-integration-into-the-current-civil-and-construction-engineering-technology-curriculum https://doi.org/10.18260/3-2-370-31517

Kangude V, Rodrigo S. Jamisola and Emmanuel K. (2021). A review on drones controlled in real-time.: International Journal of Dynamics and Control 693. https://www.researchgate.net/publication/348252556_A_review_on_drones_controlled_in_real-time

Labovich, M. (2017). What are the opportunities for and challenges to drone powered solutions? Retrieved on May 01, 2018 from https://www.pwc.ch/en/publications/2017/pwc_drone_powered_solutions_report_2017_en.pdf

Maghazel O and Netland T. (2020). Drones in manufacturing: Exploring Opportunities for Research and Practice: Journal of Manufacturing Technology Management vol.31(6), 2020

Mahajan, G. (2021). Application of Drone Technology in Construction Industry: A study 2012-2021. International Journal of Engineering and Advanced Technology (IJEAT)Vol 11 Issue 1 ISSN: 2249-8958

Matus, T. and Mesaros, P. (2019). Utilizing Drone Technology in the Civil

Mundher Alsamarraie, Farid Ghazali, Zaid Hatem, Alhamza Yassin Flaih (2021). A review on tghe benefits, barrier of the drone employment in the construction site. Journal Teknologi. Vol 84 Issue 2 pp 121-131. eISSN 2180-3722 https://doi.org/10.11113/journalteknologi.v84.17503

Nitha , M., Syeeda , S., & Maroua , M. (2022). Application of drine technology in construction projects: A systematic Literature review. International Journal of Research. ISSN 2350-0530. https://doi.org/10.29121/granthaalayah.v10.i10. 2022.4810

Noor, N. M., Mastor, I. Z., & Abdullah, A. (2018). UAV/Drone Zoning in Urban Planning: Review on Legals and Privacy. Proceedings of the Second International Conference on the Future of ASEAN (ICoFA) 2017 – Volume 2, April, 855–862. https://doi.org/10.1007/978-981-10-8471-3_84

Ngadiman, N., Kaamin, M., Muhammad Akmal Hakim Mohd. Nizam, Muhammad Afnan Hariz Johar, Muhammad Aliff Roslin. (2021). Unmanned Aerial Vehicle (UAV) Visual Monitoring in Construction. Annals of the Romanian Society for Cell Biology, 3097–3104. Retrieved from http://annalsofrscb.ro/index.php/journal/article/view/415

Patel, Umesh & Raichura, Chintan & Pitroda, Dr. Jayeshkumar. (2021). CONSTRUCTION SAFETY MANAGEMENT IN CONSTRUCTION PROJECT. 9. 435-440. Yıldız, Serkan & Kivrak, Serkan. (2021). Using drone technologies for construction project management: A narrative review. Journal of Construction Engineering, Management & Innovation. 4. 229-244. https://doi.org/10.31462/jcemi.2021.04229244

Sharma M. (2019). Major Benefits of Using Drones in Construction: https://geospatialworld.net/videos, 2019.

Sobola M. (2021). Drones: A valuable tool for the construction jobsite: https://constructiondefectjournal.com/archives/construction-news/2021/03/drones-valuable-tool-construction-jobsite

Srewil, Y. (2016). Feasibility of use UAVs (drones) in construction. Retrieved on April 17, 2018 from https://doi.org/10.13140/RG.2.2.15098.34240

Vergouw B. (2016). Chapter 2 Drones Technology: Types, payload, applications, frequency spectrum issues and future developments cited in book:B. Clusters(ed): The future of Drone Use, information technology and Law series 27 https://doi.org/10.1007/978-94-6265-132-6_2

Winters L. and Sobola M. (2021) Drones: A vehicle tool for the construction jobsite: https://www.constructionexec.com/article/drones-a-valuable-tool-for-the-construction-jobsite

Xu, C., Liao, X., Tan, J., Ye, H., & Lu, H. (2020). Recent Research Progress of Unmanned Aerial Vehicle Regulation Policies and Technologies in Urban Low Altitude. IEEE Access, 8, 74175–74194. https://ieeexplore.ieee.org/document/9080597

Yamani Yahya, M., Pao Shun, W., Yassin, A. M., & Omar, R. (2021). Journal of Technology Management and Business The Challenges of Drone Application in the Construction Industry. Journal of Technology Management and Business, 8(1), 20–27. http://penerbit.uthm.edu.my/ojs/index.php/jtmb

Yan Li & Chunlu Liu (2019). Application of multirotor drone technologies in construction management. International Journal of Construction Management. Vol 19 Issue 5 pp 401-412. https://doi.org/10.1080/15623599.2018.1452101

Yi W and Sutrisna M. (2020). Drone Scheduling for Construction Site surveillance: onlinelibrary.wiley.com https://doi.org//doi.org/10.1111/mice.12593, 2020.

Yoo, S. (2021). Proposal of improvement measures according to the limiting factors for the use of drone technology: Cases in the construction field. International Journal of Internet, Broadcasting and Communication, Vol 13 Issue 4, pp 30–38. https://doi.org/10.7236/IJIBC.2021.13.4.30.