

## **Proposal of improvement measures according to the limiting factors of the use of drone technology : Cases in the construction field**

Soonduck Yoo

*Professor of Business Administration, Hansei University, Republic of Korea*  
*koreasally@gmail.com*

### **Abstract**

*This research explored methods for improvements to be made within the field of drone usage within the construction industry based on an investigation of factors which limit their efficiency and productivity. Limiting factors and improvement measures were presented in terms of technology, service, law and policy for employing drones at construction sites. Our first suggestion is, from a technical point of view, that companies need to expand professional manpower and infrastructure for systematic management. Second, in terms of service expansion, it is necessary to have management capabilities for operation such as the use of drones with enhanced safety and reinforced on-site education and personal information management. Third, in terms of legal and institutional support measures, it is necessary to prepare a plan for reforming the legal system for revitalization and to expand the training of professional manpower. This study may contribute not only to the development of drone technology, but also to effectively respond to various problems that appear at construction sites.*

**Keywords:** *Drone, Construction, Limiting Factors, Improvement Methods, Case Study.*

### **1. Introduction**

Several technologies are integrated with each other in order to apply drones within different environments. The location information used in drones is a coordinate system and is based on a geographic information system. In addition, sensing technology such as cameras are required to take pictures through drones.

Control and monitoring of drones is within the realm of wireless communication technology. Technology to analyze and manage information collected through drones is required. Drone technology, which stands as an example of convergence technology, is being employed in various fields. In particular, the need for research on the use of drones in a construction environment is emerging.

Further research is needed on how drones can revolutionize how construction sites operate. It then follows that research on how to secure work efficiency and safely use drones, and how to improve the system for doing so should also be accompanied [1].

This study exposed the limiting factors for drone technology to be employed at construction sites, and possibilities for how to address them. Thus, it may contribute not only to the development of drone

technology but also to effectively respond to various problems that appear at construction sites.

## 2. Theoretical Background

### 2.1 Drone Technology

An unmanned mobile vehicle (drone) is defined as a mobile object that recognizes the external environment, judges certain situations by itself, moves remotely, and performs an ordered mission if necessary. An unmanned moving object here is used interchangeably with various terms such as unmanned system, autonomous system, robot/autonomous system, and drone.

In the early days, drones were developed for military use and used as targets for the US Air Force's missile bombing exercises. But gradually their use expanded to reconnaissance and attack aircraft. Recently, as the commercial use of global companies such as DHL, Amazon, and Google increases, the value of use in various fields is increasing.

Drone-based technologies can be broadly classified into hardware and software-based technologies; hardware being the physical equipment for use in the field, such as drone equipment and cameras, and software being systems which store and analyze data collected by drones, as well as a control system that manages drone operations.

### 2.2 Reasons for using Drones in Construction Sites

There are many advantages to employing drones at construction sites, including their ability to cover a large area in a short time and to take aerial photos precisely. In addition to this, due to their miniaturization, they are far safer and cheaper than other aerial vehicles [2]. Figure 1 is a photo of a case study applied to a drone-based construction site, which was cited from the Gyeonggi-do research report.



**Figure 1. Application of drones to construction sites**

Civil engineering and construction sites are suffering from a severe shortage of manpower due to the low birth rate and aging population in South Korea. Currently, the reality is that foreign workers are being put into field work. The root cause of domestic workers' avoidance of construction work is that they are exposed to poor working conditions and accidents. Therefore, it is necessary to reduce the accident rate at the workplace and secure a safe working environment.

In other words, in a situation where there is a shortage of manpower, in order for the construction industry to improve infrastructure and secure work efficiency, it is necessary to find methods for increasing the efficiency of construction sites and reducing the required labor force.

For this purpose, methods are being introduced to identify and respond to situations in real time through aerial photography by introducing drone technology.

The following are representative areas where drone technology can be applied to construction sites.

**Table 1. Examples of drone application areas at construction sites**

Item	Contents
Current status survey	Complaint response
Obstacle investigation	Obstacles also overlap
Ready-made measurement	Increased accuracy
Slope history management	History management maintenance
Tunnel construction (earth work)	Quantity output
Fair reporting	Decision
Construction review	Work efficiency
Crack investigation	Completion inspection
Inter-stereo structure interference review	Large structure decision making
Safety/Environmental Assessment	Safety Reinforcement

The reason drone technology can be applied to various factors such as industrial sites is that it can dramatically reduce the cost on the field compared to previously existing equipment and current operation services [3,4].

Therefore, when applying drone technology to field work, it is necessary to study what kinds of equipment to use, as well as what kind of data to acquire and how to process it. In addition, in order for drones to be introduced into construction sites, active awareness of the use of drones by field experts must be expanded.

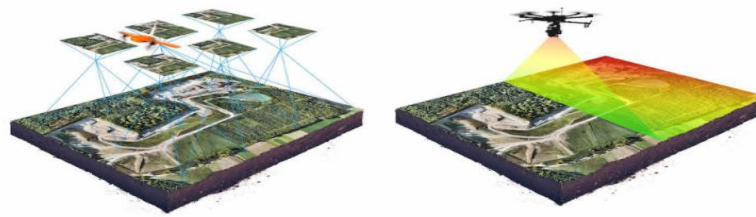
### 3. Application area example

#### 3.1 Measurement with a 3D Laser Scanner

In civil engineering and construction sites, measurement work is required. In the already-existing method, workers measured the location, distance, and area of the land using a dedicated measuring instrument.

More extensive, dangerous, or otherwise inaccessible locations have often been measured using aircraft.

However, this method consumes the high cost of renting an aircraft and may result in inefficiencies that could consume much time to reshoot if any errors occur. Therefore, the use of drones can solve the problems of the previous methods described, and at a lower cost. In other words, photos taken by drones can be used for measurement tasks [5]. Figure 2 describes an example used to produce 3D spatial information by acquiring ground information through drone photography.



**Figure 2. Surveying using rim drone photos**

As such, employing drones can significantly reduce work time, minimize risks, and enable high-precision measurement and design compared with conventional surveying methods.

**Table 2. Advantages of using drones at construction sites**

Item	Contents
labor saving	Save time and labor to collect survey data
low cost	Reduce costs compared to aircraft surveys
hazardous area access	It is possible to survey dangerous places where people cannot enter
time-saving	Even large and complex terrain can be accurately surveyed in a relatively short time
increased precision	Acquiring 3D data enables high-precision design

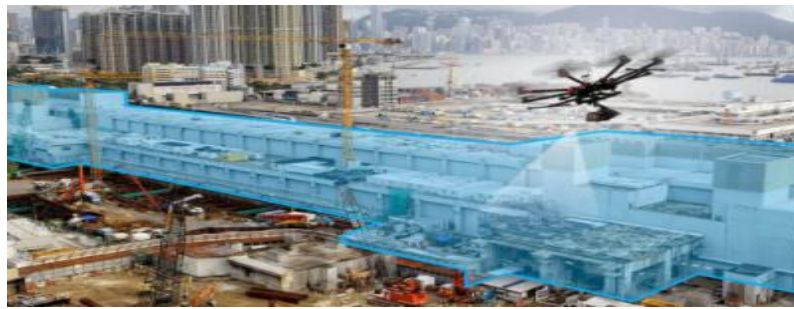
### 3.2 Construction Management Through on-site Photography

Civil engineering/construction sites take photos of the business site before and after construction begins, and then use these photos to conduct on-site construction and process management. In addition, the progress of the work is recorded as a 3D image and used for construction management.

The existing method used a facility work vehicle or helicopter for filming at the construction site, but now drones can safely perform that role. In the case of a drone, if a designated location and route are provided, it automatically returns after operation and can be used in the field with minimal management. The drone can be operated remotely, and the operator can take pictures of difficult-to-reach places. Foreground photos are also taken from various angles to help manage construction.

In addition, drones can help manage the safety of a site by quickly traversing the workplace performed by the operator. By taking pictures of the completed construction as well as inspections with drones, it is also possible to reduce construction errors or find insufficient parts at an early stage. Thus, cost reduction and work efficiency in the construction industry can be secured.

Currently, high-performance cameras can check concrete lifting, leaks, and holes. When a problem occurs at night work sites, the manager can respond quickly by checking the site situation and providing it to the control system, etc [6]. Figure3 is an example of tracking problems by using the situation of a construction site through drone photography.



**Figure 3. Construction site management**

In the study of Gheisari, Masoud, Javier Irizarry, and Bruce N (2014), the user participation assessment conducted a simulation task to verify that the operator complies with the use of necessary personal protective equipment in a controlled environment. This experimental approach has shown that the use of unmanned aerial systems (UAS) with a large interface on a tablet device can be used to provide an accurate job site assignment useful for safety-related tasks.

Recommendations for essential features of an ideal UAS for construction safety applications include, inter alia, autonomous navigation, voice interaction, high-resolution cameras, and collaborative user interface environments. The ultimate goal of this effort is to create a workplace free from hazards affecting workers, the most valuable resource of the construction industry [7].

Obradović, Ratko, Ivana Vasiljević, Dušan Kovačević, Zoran Marinković, and Robert Farkas (2019) present an example of a bridge during construction in Novi Sad for the purpose of a construction inspection carried out by the Spanish-Italian consortium, AZVI. Twice a month, they sent photos taken by drone and high-resolution film to AZVI. In this way, the contractor was able to obtain up-to-date information on the progress of the work without the presence of a company engineer. Drone shooting enables high-resolution images and videos, enabling high-quality remote inspection and reducing the number of site visits and supervision naturally [8].

### **3.3 Building Aging Management**

Drones are also being used to maintain and manage the lifespan of buildings. In order to extend the lifespan of various facilities and maintain their functions, it is very important to diagnose conditions in a timely manner and give necessary recommendations. In the case of developed countries within Europe, the market for maintenance of old buildings is quite large; there is a large number of historical buildings, which have a preservation value and are legally prohibited from being demolished for the construction of new buildings. As such, in the facility maintenance market, which is rapidly growing mainly in developed countries, the possibility of using drones for facility condition monitoring is receiving great attention.

In particular, as South Korea continues to construct high-rise buildings, drones have been employed to photograph locations that would be difficult to access otherwise, such as the exteriors of high-rise buildings for maintenance and management.

### **3.4 Operational Management such as Road and Canal Construction**

Rathinam et al. (2008) studied a monitoring method using drones for roads and canals.

In this case, a method of maintaining roads and canals and linking location information by correcting

images acquired by drones was suggested (Rathinam et al. 2008) [9].

Harwin and Lucieer (2012) studied coastal erosion and topography changes using drones. Proposals were made to respond to construction work according to changes in the structure of the shoreline using drones [10].

Martinez and Jhonattan G (2020) investigated the adequacy of a method to perform safety planning and monitoring on a high-rise construction site in Chile with a limited number of safety managers using unmanned aerial vehicle (UAV) technology and generated aerial video content. The case study involved three steps: (1) understanding the current safety planning and monitoring process of a high-rise construction project, (2) investigating how UAV-related tasks and generated visual content could be integrated into the current process, (3) How such UAV integration could impact current safety planning and monitoring processes was evaluated.

The results of the case study provided a detailed overview of the new steps required to integrate UAVs into current safety planning and monitoring processes, and argued that the adoption of UAV technology has improved risk identification and assessment in high-rise projects [11].

## **4. Limitations of Drone Application in the Construction Industry and Improvement Plans**

### **4.1 Limitations on the Application of Drones within the Construction Industry**

In all stages of the construction industry's life cycle (planning, design, construction, maintenance, and dismantling), the innovation of drones is still mostly in its infancy. In order to spread the use of drones, it is necessary to identify limiting factors that appear in the field and establish countermeasures. The following summarizes the limiting factors that appear when using drones in construction sites.

First, from a technical point of view, images of construction sites are captured through drones, but currently, most construction projects do not have a system that can analyze and process images collected by drones. It is not only important to obtain images through a drone, but it is also necessary to use them to improve service efficiency, and for this, it is important to provide a system that can analyze the images. When acquiring images using a drone, the camera shooting position may change frequently in three dimensions. Therefore, technology that can recognize and process an object's size, angle, distortion, etcetera may change depending on the shooting point that is needed. There is no way to interpret and manage images to respond in the field. In addition, there is a lack of any official system that can store and utilize this kind of data.

Second, in terms of service, there is a large risk of physical accidents at construction sites. Construction sites in particular often have structures that may be complexly arranged, which may increase the chance for collision, thus harming workers or even the construction site itself.

Third, drones currently lack the ability to manage various types of information that needs to be protected, as well as the protection of personal information for construction personnel filmed through drone images. It is insufficient to establish a process for collecting, storing, analyzing, and disposing of information captured in the field through appropriate procedures and steps.

Fourth, in terms of legal systems, there are obstacles to drone employment such as prohibited areas. In Korea, in accordance with the Radio Waves Act and Aviation Act, the operation of drones is prohibited

within a 5.5 km radius of an airport, at an altitude of 150 m or higher, near the cease-fire line, over the city of Seoul, in no-fly zones, and also over densely populated or over-crowded areas.

Fifth, there is administrative complexity for using drones [12]. In the case of the United States, effective countermeasures against administrative complexity and regulations have been presented [13]. In order to operate a drone in a restricted airspace, a flight plan must be approved by the Capital Defense Command four days before the flight. Therefore, in circumstances such as a construction site, it is difficult to use drones while complying with the above regulations, as monitoring demand occurs irregularly and frequently.

Sixth, it is difficult to secure professional manpower to perform drone work at construction sites due to the lack of professional drone operators. Only recently have drones developed into a growing field, requiring increasingly more professional manpower.

The most difficult part of carrying out various related projects is the lack of drone experts with various experiences within the construction field. Even if they have already secured drone-related manpower, construction companies are reluctant to invest in a support system that can operate and utilize this manpower.

## **4.2 Improvement**

In order to apply drones to construction sites, it is necessary to find ways to overcome various limiting factors. The following is a summary of improvement plans for the above-mentioned limiting factors.

First, in order for companies to effectively use drones at construction sites, they need to build an infrastructure that can effectively perform tasks such as operation systems for data analyses such as control and images. There may be investment costs, but these are more profitable and are necessary for safe construction site management.

Second, drones used in construction sites must be equipped with highly reliable anti-collision navigation systems. In addition, it is possible to reduce the expected risk of accidents by strengthening safety education at construction sites and using drones with excellent safety and performance ratings. Currently, a variety of drones are appearing on the market that are automated and have the ability to perform tasks according to a designated airspace and to automatically return, providing a stable environment for use.

Third, management capabilities and data collection, storage, analysis, and disposal procedures for operation such as personal information management should be established and implemented. Therefore, information generated by individuals and companies can be safely managed.

Fourth, it is necessary to systematically change and review flexible measures that consider work efficiency through detailed reviews of prohibited areas. Now that this technology is widely available, it is necessary to discuss the regulations regarding prohibited areas for drones in order to respond to technological development and changes in the environment.

Fifth, even in the case of areas where drones can be operated, the administrative procedures for obtaining permission to do so should be simplified. In order to apply drones to the field, unnecessary procedures must be boldly removed and the promptness of administrative work requests such as reports and civil complaints must be secured so that they can be practically helpful. This can serve as a catalyst to support the expansion of services using drones in the field.

Sixth, in order to solve the shortage of professional manpower in the field of drone technology, efforts should be made to continuously nurture professional manpower. In the case of construction companies, an environment is emerging where they can respond professionally to tasks such as drone usage and

employment. Cost saving measures through outsourcing of drone application work at construction sites can also be considered.

**Table 3. Limiting factors and improvement plans for using drones at construction sites**

Item	limiting factor	Suggestion for improvement
Technology	Lack of image interpretation and management plans	Establishment of professional manpower and utilization infrastructure for companies to systematically manage
Service	Risk of safety accidents in construction sites Absence of various information management capabilities and the environment	Reinforcement of on-site education and the use of drones with enhanced safety, Securing administrative management plan for managing and operating collected information such as drone shooting data
legal system	Legal obstacles such as no-fly zones Administrative complexity for utilizing drones	Revise the legal system for revitalization, expansion of professional manpower training

## 5. Conclusion

Drone-related markets are expected to grow rapidly in foreign countries such as China and the United States, and are being used in various fields. Construction sites, in particular, is one of the fields where the use of drones is being applied the fastest, and is proving their efficiency.

This study discussed factors related to improvement based on the investigation of limiting factors in order to operate drone technology at construction sites. In order to apply drones to construction sites, limiting factors and improvement measures were discussed in terms of technology, service, law, and administrative aspects.

First, from a technical point of view, companies need to acknowledge and discuss professional manpower and infrastructure for systematic management. Second, in terms of service expansion, it is necessary to have management capabilities for operation such as the use of drones with enhanced safety and reinforced on-site education and personal information management. Third, in terms of legal and institutional support measures, it is necessary to prepare a plan for reforming the legal system for revitalization and expansion of training of professional manpower.

This research will contribute to not only the development of drone technology but also to effectively respond to various problems that appear at construction sites.

The limitation of this study is that it was written based on the opinions of several drone experts, but not the opinions of many professionals and laymen in the construction field. Continuous research is needed on additional problems that arise as drones are applied to construction sites.



## Acknowledgement

This research was carried out with the research grant (21CTAP-C163557-01) of the Ministry of Land, Infrastructure and Transport's Land, Transport Technology Promotion Research Project.

## References

- [1] In-Hyun Kim, Drone technology, market trends and commercialization prospects and major tasks seminar, Industrial Research Institute, 2015.
- [2] <https://www.geospatialworld.net/blogs/an-aerial-view-of-the-future-drones-in-construction/>.
- [3] Li, Yan, and Chunlu Liu. "Applications of multirotor drone technologies in construction management." *International Journal*, 2020.
- [4] Lin, Andrew. "Use of drone technology on commercial construction projects. 2018.
- [5] <https://wingtra.com/drone-photogrammetry-vs-lidar>.
- [6] <https://unmanned-aerial.com/software-company>.  
-brings-drones-enhancing-automating-facility.  
-inspections.
- [7] Gheisari, Masoud, Javier Irizarry, and Bruce N. Walker. "UAS4SAFETY: The potential of unmanned aerial systems for construction safety applications." In *Construction Research Congress 2014: Construction in a Global Network*, pp. 1801-1810. 2014.
- [8] Obradović, Ratko, Ivana Vasiljević, Dušan Kovačević, Zoran Marinković, and Robert Farkas. Drone aided inspection during bridge construction, In *2019 Zooming Innovation in Consumer Technologies Conference (ZINC)*, pp. 1-4. IEEE, 2019.
- [9] Rathinam, S., Kim, R., and Sengupta Vision-Based Monitoring of Locally Linear Structures Using an Unmanned Aerial Vehicle, *Journal of infrastructure systems*, 14(1), 52-63, 2008.
- [10] Harwin, S., and Lucieer Assessing the Accuracy of Georeferenced Point Clouds Produced vis Multi-View Stereopsis from Unmanned Aerial Vehicle (UAV) Imagery." *Remote Sensing*, 4(6), 1573-1599, 2012.
- [11] Martinez, Jhonattan G., Masoud Gheisari, and Luis F. Alarcón. "UAV integration in current construction safety planning and monitoring processes: Case study of a high-rise building construction project in Chile." *Journal of Management in Engineering* 36, no. 3 2020: 05020005.
- [12] Jae-Min Kwak, Hyun-Taek Lee, *Drones, Regulations Squeezed Out of Korea and Unable to Be Usable*, 2016.
- [13] Seungwook Kim, *Regulations on Police Use of Drones, US Legislative Cases and Domestic Implications*, 2018.