Construction Project Management Using Drone And Photogrammetry For Residential Building

Pankaj D. Kute[1], Prof. Mohammad Iqbal[2], Prof. Sarang. M. Dhawade[3]
[1, 2] Dept of Civil Engineering
[3]Assistant Professor, Dept of Civil Engineering
[1, 2, 3] VYWS's PRMCOEM, Badnera-Amravati

Abstract- *An unmanned aerial vehicle (UAVs), is also known as drone technology, is used for different types of application in the civil engineering. The drone previously has risen in military applications for spying and to get mapping area specifically to the construction project, the drone can be applied as a tool for visual inspections process such as area mapping, tracking work in progress, inspections of built up structure and locating and identifying construction defects.Ageing and fatigue of infrastructures has become a major concern especially for elevated highway and bridges where the service life is shorten. Therefore it requires an optimized procedure and the use of drones is explored within this study. This study, aims at the application of technology which is drones for structural/construction inspection through visualization approach. The aim of this study is to offer greater perception in what's vital to inspire the construction industry to enforce drones. This can be completed through answering the primary studies query: "What is the belief of the application of drones in the construction industry?" In order to reply this query it changed into first researched what drones should do in the construction industry. This is typically with the usage of cameras. One of those applications of drones may be engaging in visual inspections of objects at top at the same time as the operator is secure at the ground. This isn't best safer; it's also lots quicker than sending an inspector to a roof. The ability customers of the studies have been observed to be contractors, nearby governments and consultancy agencies. After the literature have a look at a survey and interviews have been placed together. The questions requested in the the survey has been primarily based totally at the final results of the literature study. The survey was distributed under the ability users observed in advance in the studies. In order to get top perception in what the potential users of drones assume drones to do there have been additionally three interviews conducted. These interviews gave a fantastic extensive view to the expectancies the ability customers have of drones. The consequences of the survey and interviews have been processed and the facts analyzed through evaluating the outcomes. After this, conclusions and recommendations have been drawn.*

Keywords- UAS, UAV, drone technology, construction projects, etc.

I. INTRODUCTION

1. For conventional method of visual inspection on high reach point it always have a current issues involving limitation of machinery such as sky lift and human error.

2. Although conventional method of visual inspection must be an efficient way throughout current time but still it can be questionable on:

(a) Time effect
(b) Cost impact
(c) Efficiency in co-ordination
(d) Legal documentation for court issues
(e) Safety and health perspective
(f) Business perspective

3. So this research involves a study to attempt an answer for this problem and to propose combining technology with construction area specifically in visual inspection area.

II. OBJECTIVES

a) To study immersive technologies can be used to enable controlling construction projects remotely, applying/checking end users requirements, construction education and team collaboration.
b) To monitor a Case Study on Drone Technology & its application in construction industry through the questionnaire survey and expert interviews.

III. DATA COLLECTED BY SURVEY

Eventually there were 22 respondents. Ten of those respondents eventually turned out to be not usable at all, one of them seemed to be a hoax only filling in he was a safety guard working for the consultancy. Four respondents only filled in the section B questions and the other five only filled Section A questions only i.e. in what their function was and/or at what type of organization they were working. Three of the

respondents eventually stopped halfway at Section C questions. These responses are still kept as Section C questions answers are still useable for the outcome of those questions. The answers given can be found through tables and diagrams in Appendix A. When we look at the survey, we see most of the respondents are consultants or members of management teams of consultancy agencies or contractors. The respondents think they use imagery in most of their cases with the biggest category being between 61-80% of their total projects and the second most chosen category is the even higher one with 81-100% of usage of imagery in projects. We can also conclude that out of this group there was no one who thinks they will be using less imagery in the future, half thinks that they will increase the amount of imagery made and the other half says they will continue making the amount of imagery they were already doing. If we look at the object that imagery is made of this is mostly the object as whole, imperfections, progress of the project and the work in progress itself. Less popular subjects being photographed are electrical systems, piping- and plumbing systems. The most preferred method of shooting imagery turned out to be by smartphone (9 out of the 12 respondents), with the compact camera as a close second (7 out of 12 respondents), one of the respondents gave a drone as a way to make imagery. The smartphone also turned out to be the most useful device of making imagery with an average score of 8.8/10 for usefulness, this time followed by the DSLR with 7.9/10.The imagery is mostly used for internal communication and external promotion (both were filled in 8 times), inspections were also an important use of imagery (6 times filled in). To the question about the shooting of thermal imagery almost all of the respondents answered they use thermal imagery for about 0-20% of their projects. During the finishing and usage of the project the most imagery is taken and the main reasons to make imagery are internal and external communication. Both method of communication were appointed 8 times versus the 6 times inspections were mentioned as usage for the imagery. Real-time imagery turned out to be fairly useful to neutral, so it is a nice bonus, but had no real added value according to the results of the survey. Most people think they are familiar with drones, no one has not already heard of a drone, 9% has heard from a drone and the rest knows what drones are or have even flown with one. The respondents think that drones would be most useful to shoot imagery of rooftops and objects as whole. The respondents of the survey would use a drone to make imagery within the range of 0-40% of their projects (45% said 0-20% and another 45% said 21-40%). But when asked if a drone could be a problem in the construction industry 73% of them say drones could be a problem indeed for a variety of reasons (privacy, regulations, it is new for the industry). One person said drones in his opinion only have added value for the construction industry. One person came with the suggestion to use drones to scare away nesting birds another person gave the option of using Google Glass as form of imagery on construction sites.

IV. DATA COLLECTED BY INTERVIEW

Here the results of the interviews will be presented. The full results can be found in Appendices B, C and D. The results of the interview with company K and L are combined because they were retrieved from a meeting of both companies followed by an interview to company M.

Company K & L: The meeting with company L, a company that was planning to use a drone within their work environment, and drone builder company K gave a lot of insight about the regulations regarding drones. Unfortunately the surroundings were too noisy to make recordings and connection was quite poor, so the researcher made extra notes and processed the conversations partly from memory. The proceedings of the meeting and combined interview can be found in Appendix B. Company L is interested in using a drone to measure the rooftops of buildings in high rise building. These measurements are now done by hand and need to be done twice. The first time will be a rough measurement in order to get a price indication to the customer; if the customer agrees a second, accurate, measurement will be done. This cost time and company L believes a drone could do this work much faster for them with the added bonus of working safer from the ground instead of on the roof.

Company K can offer the total package of the drone including the software that can be used to make the measurements or make an export to CAD to make the measurements in CAD if wanted. The drone flies autonomous with the help of a programmed flight path which uses Google Maps. Respondent A of company K also made clear operating a drone needs special training and a lot of paperwork needs to be arranged before it is allowed to fly the drone in The Netherlands. Implementing an infrared camera to the drone is also possible, but company L was not interested in this technology.

It also was mentioned that obstacles do not form a problem for the scanning of the roof because the technology uses a pointcloud of about 25 high quality images made by the drone and DSLR. Flight time of a drone from company K is guaranteed to 12 minutes, but since the drone will be done taking the images in about 5 minutes this faces no problem and if company L wants to use the system for 6 projects a day they could purchase extra batteries in order to keep going all day. Company L further makes use of images made by smartphones and other cameras. Google Maps is often being

used to orient the environment of a possible project. They want to improve their working speed and accuracy in order to save costs, be innovative and gain positive publicity. They do not use thermal imagery yet.

Company M: The full proceedings of the interview with respondent D, the engineer of two departments of company M in the Pune region can be found in Appendix C. Company M is a constructor and a developer. They do projects all the way from the initiative phase till maintenance. An important usage of imagery for them is communication (marketing) to their customer, but also for internal communication. For every project they use imagery, often professional photographs are hired to make these pictures. What could be seen is the rise of the importance of imagery over the last years. "Nowadays digital pictures are stored in a 'Cloud' and images are of high professional quality". Videos are often made and spread via social media like YouTube, LinkedIn, Twitter or Facebook. Imagery on the construction site is most often made from work in progress in order to guarantee the quality company M delivered. They also use special software application that store imagery so it is possible to check how something is done on a later moment in time. The pictures on site are more including people in them in order to make them more attractive for marketing purposes. Google Earth and Streetview are mentioned as imagery that is also used a lot. Every device for making imagery is being used by company M, from smartphones to webcams. The webcams monitor the progress of the project and offer a semi real-time image of the site. Recordings are delayed 30 minutes in order to prevent spreading if an accident happens. Company M also uses sensor triggered cameras to secure the site against thievery. Also infrared imagery is made in about 60% of their projects, in India respondent D thinks this rate is about 60%. The infrared imagery is being used in order to get the evidence for BREEAM like certificates. Company M owns an infrared camera, but usually hires an external specialised company to make the reports. Company M has used drones just to make video footage for marketing purposes, but respondent D knows about the possibilities for measuring that drones can offer. Respondent D believes drones could be used for a lot of applications, namely inspections of rooftops from a safe position. But he thinks drones could also do some work in the future, he has mentioned moving bricks as an example in order to save time the workers could use to actually build the building instead of getting tools or materials. Respondent D further believes drones could project measurements and construction drawings to the site in order to prevent misplacement of elements. Company M would probably not buy a drone in the future to get imagery, but would rather hire an external company to do this for them. Respondent D had his doubt about the regulations needed for flying a drone and thinks the drone might cause a distraction. Further respondent D states "if someone is not convinced a new technology will work for him he is not probable to use the technology a lot". He is not interested in what the drone is supposed to cost, but more in what it will make for company M and that is hard to say.

Company N: The full proceedings of the interview with respondent E, the project engineer of well-known construction industry in Pune for company N can be found in Appendix D. Company N is a construction company and developer that realises projects for utility construction, housing and also does renovation and maintenance projects. They use imagery mainly for communicative purposes. This means communications to the customer (marketing) and internal communication in order to guard the quality company N delivers. The current form of imagery was not used 10 year ago, then it was a bundle of white drawings from an architect and now we use 3D and BIM models to visualise projects. Company N uses imagery in every project they do. On the constructions site respondent E believes imagery is just at the beginning. Nowadays the executers of company N all are given iPads with an application for quality surveillance. The worker makes a photo of it, describes what is wrong and sends it to the person who can fix it. That person accepts the work, fixes the problem and hits the button that says he is done. The work is al recorded in the logbook. This method is used by all the bigger construction companies according to respondent E. Company N uses infrared imagery for blow door tests in order to test if their construction complies with the demands given. These demands are often that the construction needs to have the BREEAM certificate. Company N hires external companies to do this for them. Video footage is also used to distribute on YouTube or other social media for marketing purposes. Occasionally company N uses webcams at construction sites for monitoring the progress of the project. Sensor triggered cameras to secure the site from thievery is also used. 3D have also been used by company N in order to make visualisation and respondent E told company N is starting to test virtual reality glasses with 3D imagery to let someone walk in a room of a conceptual building in the beginning of the construction progress. According to respondent E in the near future we will ideally see that new technologies like interactive pairs of glasses for every person on site that gives real-time to the worker what he needs to do and where he needs to do that. Most imagery in the form of pictures is shot during construction in order to monitor the progress of the project and to guard for the quality delivered. Real-time images from for example webcams are seen as an extra bonus but not for great added value. Company N had worked with drones in order to shoot aerial footage for marketing purposes. A colleague of respondent E owns a

drone. Respondent E imagines that a drone could be of added value to an executer as an extra pair of eyes. The executer can monitor the other side of the site without having to constantly walk in circles. He also believes that about 50% of the work on site is actually of added value according to the Lean principles. The rest of the time is wasted with getting tools and materials. If a drone could bring the worker his tools or materials this would improve efficiency. He also thinks inspecting a high construction would be doable with the help of a drone as a replacement for scaffolds. Or other hard to reach areas like crawl spaces if the drone would be very small and able to fly indoors. He also thinks drones should be able to fly autonomously via a predetermined route. Respondent E thinks another use for drones would be for the infrastructure industry. The often need level heights or need to know how much sand there is in the heap of sand. That could be determined with the help of a drone (quad or fixed wing). The doubt respondent E has with drones lie with the regulations around drones and the fear people have for their privacy and the distraction a drone would create excludes its use around working times.

V. VALUATION OF DRONES

The fact that both the survey and one interview gives that they would use a drone to shoot imagery for somewhere around 20% of their projects indicates that drones have added value for the user. Given in the interview with respondent D is that the cost of drone technology does not matter too much, the added value is what counts. Not one of the respondents was able to get an indication to the amount of money they were willing to pay for a drone or drone inspection. The meeting with Company K and L made clear a drone capable of making measurements with the proper papers and training for the operators would cost which would be a lot of money if one would only take some pictures and shoot some promotional videos with it. But if operated for cost reducing activities to their 27 work, a cost reduction a year would make the drone break even. This seems to be an easy task given the time a drone could spare a company. Yet still it seems people are too afraid to take the step towards the usage of drones.

VI. ADVANTAGES/DISADVANTAGES OF DRONE

Attributes	Theoretical outcome	Empirical data
Relative Advantage	Drones offer a relative advantage to alternatives when working at height and offering a contractor an extra pair of eyes on site. Also, drones supersede 3D laser scanning because a drone will make a 3D scan faster and does not require a stable underground. A disadvantage of drones is that they do not operate in bad weather conditions.	Drones save time, and therefore money. Using drones would also increase safety. Disadvantages found were violation of privacy, the fear of a crashing drone and the regulations regarding drones in the Netherlands.
Compatability	For this attribute the results of the empirical data were needed. Drones are not compatible with the current values for privacy, but drones are in line with the increased usage of imagery in the construction industry.	The needs the potential user has for a drone relies heavily to the purpose he has for the drone.
Complexity	Drones need two persons to operate the drone itself and the camera mounted to it. Nowadays drones can also fly autonomously using GPS. The complexity of flying a drone has gotten lower because of this GPS, but a drone itself remains a complex divide.	Drones are getting more autonomous using waypoint flight-paths with the help of Google Maps. Which makes it easy to operate, but regulations in The Netherlands are very strict and require a lot of complex paperwork.
Trialability	Trialability depends on the application the user wants for the drone. If a professional drone is required triability is low because of the high investment costs and regulations around these drone. If a (high-end) consumer drone would be sufficient the investment cost are not so high making them a lot more triable.	The high price of a drone decreases the degree of triability, this will further decreased because of the regulations in India.
Observability	From other industries it can be seen that drones give advantages compared to the older methods.	Drones can be seen in a lot of places and opinion are divided. But using a drone in the construction industry would form a good marking position. A downside is that a drone often forms a distraction. This would make a drone in the construction industry dangerous to the workers.

VII. CONCLUSION

The results found in the literature study were not always very conclusive. Information found was about the subject, but in another industry or setting. This is because the combination of drones in the construction industry is new and there is no real research conducted about this specifically. The surveys response rate was very low, regardless of the attempts of the researcher to spread the survey. The link on LinkedIn page of the supervisor is believed to be a turning point for the survey. Before this link was posted, in a feedback moment with the supervisor, it was decided to start with interviews to support the survey for gathering empirical data for the research. It was intended to record every interview, however, the meeting between company A and company B was found disturbances due to less speedy network at other side of call. That made recording the meeting and interview afterwards impossible. The interview was also not fully conducted as was intended, but this was because a lot of the questions that were going to be asked in the interview were already answered in the meeting between the companies A & B. When the survey results were exported to Excel it turned out that some of the respondents only filled the first couple of questions in, these did not add any usable information to the research so they were neglected. There was one respondent that stopped with

the survey halfway. The results of this respondent for the first 8 questions were processed.

VIII. ACKNOWLEDGEMENT

I am highly grateful to thank my guide, Prof. Mohammad Iqbal, Prof. S. M. Dhawade, Department of Civil Engineering (CE&M), PRMCOEM Badnera- for their constant intellectual support in the form of innovative ideas and valuable guidance. Their expert suggestions and scholarly feedback had greatly enhanced the effectiveness of this work.

REFERENCES

[1] Suraj G. Gupta et al. '*Review of Unmanned Aircraft System (UAS)*', International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), pp. 1646-1658, April 2013.

[2] Prof. Neil D. Opfer et al. '*Unmanned Aerial Vehicle Applications and Issues for Construction*', 121st ASEE Annual Conference and Exposition, June 2014.

[3] Javier Irizarry et al. '*Exploratory Study of Potential Applications of Unmanned Aerial Systems for Construction Management Tasks*', American Society of Civil Engineers, 05016001 1-10, 2016

[4] Jesse Sanchez '*Applications of Drone Technology with BIM to Increase Productivity'*, 2016.

[5] William Wilkins et al. '*Drone Surveying: 3-D Enabled Automation of Roofing and Building Envelope Structures'*, 32nd RCI International Convention and trade Show, pp. 247-263, March 2017.

[6] Mark C. Tatum et al. '*Unmanned Aerial Vehicles in the Construction Industry'*, 53rd ASC Annual International Conference Proceedings by the Associated Schools of Construction, pp. 383-393, 2017.

[7] Brodie Y M Chan et al. '*Photogrammetric Modeling for Bridge Inspection and Remediation*', 8th Australian Small Bridges Conference, 2017.

[8] Hazim Shakhatrehet. al. '*Unmanned Aerial Vehicles: A Survey on Civil Applications and Key Research Challenges'*, April 2018.

[9] Naveed Anwar et al. '*Construction Monitoring and Reporting using Drones and Unmanned Aerial Vehicles (UAVs)*', The Tenth International Conference on Construction in the 21st Century (CITC-10), July 2018.

[10] Alex Andersson et al. '*Photogrammetric 3d-Mapping using Low-Cost Unmanned Aerial Vehicle - Analysis of Accuracy*', LTH School of Engineering Lund University, 2018.

[11] Soroush Dastgheibifard et al. '*A Review on Potential Applications of Unmanned Aerial Vehicle for Construction Industry*', Research Gate Publication on Sustainable Structure and Materials, Volume 1 Issue 2, pp. 43-53, 2018.

[12] Dr. Ibrahim Motawa et al. '*Unmanned Aerial Vehicles (UAV's) for Inspection in Construction and Building Industry*', Proceedings of the 16th International Operation & Maintenance conference (OMAINTEC), November 2018.

[13] Joseph S. Sanson '*Drone Use in the Construction Industry Leads to Integration into the Current Civil and Construction Engineering Technology Curriculum*', Proceedings of the 2019 Conference for Industry and Education Collaboration, American Society for Engineering Education, 2019.

[14] Matúš Tkáč et al. '*Utilizing drone technology in the civil engineering*', SSP - JOURNAL OF CIVIL ENGINEERING Volume 14 Issue 1, 2019.

[15] Hamlet Reynoso Vanderhorst et al. '*Systematic Literature Research of the Current Implementation of Unmanned Aerial System (UAS) in the Construction Industry*', International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume 8 Issue 11, pp. 416-428, September 2019

[16] Masoud Gheisari et al. '*Using Unmanned Aerial Systems for Automated Fall Hazard Monitoring in High-rise Construction Projects*', CPWR-The Center for Construction Research and Training., October 2019.

[17] Farzad Pour Rahimian et al. '*On-Demand Monitoring of Construction Projects through a Game-Like Hybrid Application of BIM and Machine Learning*', Automation in Construction, November 2019.

[18] Efosa Alohan '*Exploring the Role of Building Modeling and Drones in Construction*', Department of informatics IT Management SPM, 2019.

[19] Pawan Kumar Mishra '*A View of the Future: Drones in Construction Industry'*, International Journal of Management, IT & Engineering, Volume 9 Issue 2, pp. 271-277, 2019.

[20] Suk Bae Lee et al. '*Change Monitoring at Expressway Infrastructure Construction Sites Using Drone*', Sensors and Materials, Vol. 32, No. 11, 2020.

[21] Anamika S. Jadon et al. '*Uses of Drones and Photogrammetry in Project Monitoring*', International Research Journal of Engineering and Technology (IRJET), Volume 07 Issue 12, pp. 1765-1771, December 2020.

[22] Michael Elstner '*Use cases of Extended Reality in the constructionIndustry*', LAB University of Applied Sciences, 2020.

[23] Javad Shahmoradi et al. '*A Comprehensive Review of Applications of Drone Technology in the Mining Industry*', Molecular Diversity Preservation International, 2020.

[24] Gayatri Mahajan '*Applications of Drone Technology in Construction Industry: A Study 2012-2021'*, International Journal of Engineering and Advanced Technology (IJEAT), Volume 11 Issue 1, pp. 224-239, October 2021.

[25] R. S. Sawant et al. '*Drone Technology in Construction Industry: State of Art*', Vidyabharati International Interdisciplinary Research Journal (Special Issue), pp. 643-648, October 2021.