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Use of Drone Video for Weekly Surveillance at Remote Site Tailings Storage Facilities

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ABSTRACT

Drone video has been used successfully for the past two years for weekly surveillance of tailings storage facilities (TSFs) under construction/operation at remote sites in the Philippines as part of an overall technical review role for the projects. This role includes full-time technical support by in-country personnel with an annual in-person field inspection by senior personnel from Australia and/or Canada. The videos are taken by mine technicians under the direction of site engineers. Technical details of the TSF construction/monitoring are then reviewed by the site team with off-site senior engineers in a weekly Teams meeting.

The videos have been found to be very useful and provide the reviewers with more information than still images. The drone route typically follows an established pattern that gives an overview of the site while more detailed close-up views can be requested by the reviewers if a particular issue arises. Most of the time, the reviewers view the videos before the Teams meeting and can then fast-forward to critical viewpoints during meeting discussion.

The video meeting format has been instrumental in the identification of issues such as potential instability of surrounding cuttings and waste rock dumps in the steep topography, poor drainage control leading to potential severe erosion, borrow area management, tailings discharge management and access road planning. The drone video also allowed a high level of technical support to site supervisory staff at the remote site that would otherwise be impossible.

Introduction

During the COVID-19 lockdown period and even in normal times, it has not been practical for a high level of detailed field inspection of construction projects in remote areas by experienced technical engineering staff. This was the case for a tailings storage facility (TSF) construction project in the Philippines. This could equally apply in developed countries, where the travel time to site covers more than a few hours. At the Philippine site, this issue was overcome using on-site, in-country technical engineering staff working on a rolling shift basis, supported by senior engineering personnel in Australia and Canada undertaking weekly Teams conferencing and an annual site inspection by the ex-pat team.

The weekly Teams conference reviewed video footage of the site. The videos have been found to be very useful and more informative than still images. The drone route typically follows an established pattern that gives an overview of the site while more detailed close-up views can be requested by the reviewers if a particular issue arises. Most of the time, the reviewers view the videos before the Teams meeting and then fast- forwarded to critical viewpoints during meeting discussion.

Drone Features

Description of drone

A drone is a flying robot or unmanned aerial vehicle (UAV) which is controlled remotely and collects data, such as survey points, video footage and photographs. From a military background, drones have evolved to be used in a range of civilian roles. Typical commercial-use drones are compact in design but can vary in size to aircraft scale. For this project, the drone used was a DJI Mavic 2 Pro (Figure 1), which features omnidirectional vision systems, infrared sensing systems, and a fully stabilized 3-axis gimbal with a 1” CMOS sensor camera that shoots 4K video and 20-megapixel photos. It is capable of connecting to a smart mobile phone for remote screen viewing and to pilot the drone.

This drone is also capable of flight plan mode which can be configured through its device setting depending on the specified location, area and pre-defined pathway.

Figure 1 DJI Mavic 2 Pro drone

A Mavic 2 Pro or similar drone retails for approximately A$3000.

Comments on practical aspects

Resolution/File Size/Time

The usual output from the drone comprises a 300-500 megabytes (mb) MP4 file at 4k resolution. This provides three (3) to five (5) minutes of viewing and is sufficient for a flying route around the TSF to give good coverage of the site from different viewpoints. Additionally, the drone allows full high definition (FHD) resolution this but was found to be impractical due to file size. The 4k resolution has been adequate for the purpose of review.

Weather Effects

It is crucial to have a detailed plan and a review of the weather forecast prior to drone operations. Wet and windy conditions will complicate the drone control and should be avoided.

Different weather elements that impact drone operations are as follows:

Precipitation / Rain event

Some drones are equipped to be waterproof, however, most cannot tolerate water and moisture. Rainwater can damage electrical components and render a drone unusable. If rain occurs during the scheduled date of drone activity, the flight should be rescheduled.

Strong Winds

Difficulty arises from flying drones during windy conditions as wind limits of drones are based on their models as indicated in the operation manual. The drone model used on site could withstand a level-5 wind resistance, which is twenty-nine (29) to thirty-eight (38) kilometres per hour (kph). Before flying a drone in wind, the battery should be fully-charged as more power is consumed during strong winds. Otherwise, the drone will slow down due to radio receiver issues because of power drainage. Consequently, if the wind speed is above the threshold, the drone operator might lose control due to momentum changes. The crucial decision on whether to continue or delay drone operations during the prevalence of strong wind should be taken into account by site engineers and drone operators.

Visibility

Fog, mist, and haze affects visibility and can block drones from view. The drone operator must always keep the drone in line of sight. Part of the drone flying activity is the flight plan, which is provided by the site engineer to the drone operator for initial assessment and overview. Any area, which has poor visibility that could potentially block the line of sight, must be double checked and rerouted or delayed as necessary.

Cold Temperatures

Low temperature can reduce battery performance, but this has not been a problem at the Philippine site.

Natural Hazards

Conducting drone activities in rural and remote areas entails careful planning. Planning includes identifying external and internal factors that could affect the flight. Aside from drones being operator-dependent as a remote-controlled device, external factors such as environmental hazards require strict planning and execution.

Topography

The limitation of flying drones in remote areas is grounded on the fact that terrain is often obstructed with dense flora. To ensure safe drone flight activities, the site engineer and the drone operator must use cautious judgement and planning to consider the difference in elevation between way-points. Obtaining survey maps of the area will provide an overview of the pre-set maximum altitude of the drone, preventing the loss of signal and possible crash.

Avians

The behavioural adaptation of birds reflects their responses to environmental situations, which includes territorial instinct. Issues with bird attack can be addressed through careful and well-thought countermeasures which include setting up a flight plan limiting interactions with their breeding and brooding patterns.

On-site drone activities are typically scheduled in the morning as large species of birds use thermals for soaring and gaining altitude. Planning drone activities early would also limit avian interactions as their flight patterns are typically observed on warmer parts of the day as the ground heats up from the solar radiation. Arguably, drones can be flown at any time, but using this measure would minimize associated risks. Bird interaction has not been a problem at the Philippine site but has been reported at several Australian sites.

Humans

Part of the risk assessment in drone activities includes the surveillance on security and safety risks to people. Surveillance should provide information dissemination on the drone flight plan and precautionary announcements to prevent potential hazards/injuries.

Procedure for video Capture

A flight plan is prepared by the site engineer using way-points plotted on a drawing plan, taking into account the key areas that the site engineer aims to capture on video. The flight plan is then discussed with the drone operator, along with instructions such as having to zoom in on specific areas, to ensure that all the necessary details are clearly shown to the viewers and allow for a more effective discussion. A copy of the drone footage is then obtained and sent out prior to the meeting to allow the reviewers to view the footage and note all the concerns that need to be raised to the site engineer and addressed by the site team.

Procedure for Technical Review

The drone videos were typically taken at the start of each week (Monday), unless weather conditions or other issues prevented this, in which case the flight would be undertaken at the earliest time. The videos were then emailed to Canada and Australian staff for review the following day in a meeting between the onsite engineer and the offsite senior engineers. The meetings using Teams were typically 30 minutes duration. The findings made during the review were then discussed by the site engineer with the client at a weekly meeting to ensure that the client construction supervisors understood the issues prior to giving out instructions to personnel in the field. The schedule was designed to capture the construction progress for the past week and give ample time for the site team to address all the concerns that were raised during the drone review meeting. The availability of video also simplified the client discussions.

An important aspect of the system of video capture and review meetings has been the responsiveness of the client and construction team in addressing the concerns of the review team.

Example findings

The video meeting format was instrumental in the identification of issues such as potential instability of surrounding cuttings and waste rock dumps in the steep topography, poor drainage control leading to potential severe erosion, borrow area management, tailings discharge management and access road planning. The drone video allowed a high level of technical support to site supervisory staff at the remote site that would otherwise be impossible.

Below are some findings discussed from drone footage weekly reviews.

Unsafe Slope upstream of the TSF

The drone image shown in Figure 2, shows a cut slope located on the right abutment of the impoundment area. This was noted by reviewers as potentially unstable with any failure potentially causing waves that could threaten the embankment. Dam design engineers notified the client of the risks and impact if not corrected immediately.

Figure 2 *Upstream batter noted to be potentially unstable*

Remediation works allowed stabilisation of the batter as shown in Figure 3.

Figure 3 *Batter after stabilisation works.*

Overtopping Risk (On-going gabion spillway construction)

Figure 4 *Gabion spillway walls lower than crest*

The drone image in Figure 4 shows the progress of the gabion spillway construction. The gabion spillway was built in stages. The reviewers noted that the raising of the spillway walls was progressing at a lower rate than the spillway crest. This meant that if there was a rise in the pond level leading to overtopping the spillway, there was a potential for unplanned spill to both sides of the spillway leading to damage and potential failure of the spillway. The dam engineers advised the client on the spillway construction sequence, with the mid-section serving as the low point and the gabion sidewall being built in advance resulting in the correct geometry shown in Figure 5 and the completed structure in Figure 6.

Figure 5 *Properly constructed spillway*

The image above shows the sequence of the gabion spillway construction which has been modified based on the recommendations of the dam engineers. This includes the construction of the gabion side walls before the gabion steps to ensure that the flow is directed into the middle portion of the spillway in case of an overtopping event.

Figure 6 *Completed spillway*

Erosion along the abutment

The drone image in **Error! Reference source not found.** shows erosion along the right abutment caused by surface run-off. Dam designers informed the client of the potential risk for instability if the erosion progresses further. **Error! Reference source not found.** shows the remediated scouring along the South abutment. Surface run-off was also diverted away from the abutment to prevent erosion from subsequent rainfall events.

Figure 7 Significant erosion on right abutment

Figure 8 *Corrected erosion*

Conclusion

Drones, which allow data collection quickly and remotely, are one of the advanced technologies that can be used for on-site dam inspections. They allow site engineers, dam designers, and owners to interact during online discussions and conduct technical online reviews and assessments of site construction progress using video footage.

Drones can serve multiple functions in construction. They are capable of capturing a clear overview of site progress for technical and non-technical viewers, providing flexibility for inspection covering specific areas of concern particularly on matters that require immediate resolution and updates, and serving as a tool to identify potential dam hazards and risks that could lead to harm, damage, and failures. Importantly they have proven an excellent tool for communication between designers and constructors to allow timely correction of issues noted by external reviewers.