Advances in Engineering Research, volume 210
Conference on Broad Exposure to Science and Technology 2021 (BEST 2021)

Implementation of Unmanned Aerial Vehicle (UAV) in the Sand Mine Project

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ABSTRACT
The significant volume discrepancy between planned targets and actual implementation in a mining project creates complex issues related to schedules, equipment and labor mobilization, and operating costs. This difference can be caused by survey methods, mapping methods, excavation volume calculations, and conventional and not comprehensive monitoring methods. Therefore, the technological action that can be taken is to use aerial photogrammetry technology using an Unmanned Aerial Vehicle (UAV), which is often called a drone, as a method for surveying, mapping, calculating, and monitoring. The use of drones can facilitate the survey and mapping process in areas that are difficult to reach, can record a wider area, the object displayed is an image according to field conditions that can be displayed in 2D or 3D, has the flexibility of temporal resolution because the drone can be flown at any time, and capable of producing large-scale map products because drones are flown at an altitude of < 20 m above ground level, so drones are considered very appropriate to be used to monitor the progress of sand mining regularly.

Keywords: *UAV, Mining Project, Survey and Mapping, Drones*

1. INTRODUCTION

Cadas gorowong sand mine project managed by CV Cadas Barokah started in 1998 and expected to end in 2020. This sand mine is a project that is not only engaged in mining activities but has other activities such as excavating, processing, utilizing and selling materials in the sand sector and manufacturing stone crusher equipment to be traded. Characteristics of a mining work project generally lie in the information relating to the value of excavation volume. Estimation of the value of excavation volume is carried out by comparing the volume of excavation at the target plan with the project excavation volume obtained periodically. The difference between the excavation volume value of the plan and the project resulted from the comparison is used as a reference for determining the next progress, mobilization of equipment and workers, and future operational costs so that the project can be completed exactly according to the contract.

So far, periodic excavation volume measurements have been carried out conventionally using terrestrial surveys, namely by placing height measuring instruments at several excavation points then calculating the height and volume mathematically. However, there is often a significant difference in the volume of excavation between the planned volume and the implementation in the field due to measurement and calculation errors.

The method of terrestrial measurement, drawing and manual calculation for a relatively large mining area have the potential to cause errors in data retrieval and processing. Natural factors or excavated topography provide different challenges and levels of difficulty for surveyors in making measurements, so that not all measurement points can be reached. This condition results in the inability to obtain detailed images following the actual topographic conditions in the field. This difference in topographic conditions has an impact on the actual excavated volume value.

Likewise with the method of supervising manual excavation work. The process of monitoring the value of the excavation volume is carried out periodically and the determination of the excavation volume target is carried out at the beginning of the work by performing linear calculations based on the number of tools and operational time which often does not change in quantity. This condition causes excavation volume monitoring activities to be considered not very important, so they only rely on the value of the excavation volume towards the end of the work. This kind of supervision method only puts the problem and solution at the end of the job.

This study discusses the implementation of drones in sand mine project activities. The mine project area is photographed and a topographic 3D model is made to visualize the sand mine excavation so the volume of excavation can be calculated.

Literature review Technological developments have made drones widely applied for civilian needs, especially in the fields of health, business, industry, and logistics. China, the first country to face the wrath of the COVID-19, has made great use of drone technology to counter the COVID-19 outbreak [1]. In the tourism industry, UAV can perform monitoring and patrol missions to protect assets and tourists at attractions in coastal areas, canyons, national parks, etc. [2]. Drones have been applied in various services such as forest fire fighting, mining exploration, mapping agricultural areas, infrastructure supervision, and mapping industrial areas. An UAV-based remote sensing system for road image acquisition and road condition parameters collection. [3]. Drone technology in the industry is used to complete tasks faster, improve work quality and safety standards also lower costs. In the construction field, drones are used as a routine inspection tool to check the age and damage to structures such as bridges or buildings [4]. Drones can provide information for personnel monitoring, activities, and progress at industrial sites as well as provide immediate feedback on actions being taken on the spot [5]. Therefore, drones have great potential in monitoring and field surveying for mining works compared to terrestrial measurement methods.

During the land clearing and mining activities, drones are used as a tool for open mining documentation, restoration monitoring, and inspection [6]. In the post-mining phase, drones are used to mapping rehabilitation of their post-mining landforms repeatedly in a flexible and cost-effective manner compared to terrestrial measurements which require large amounts of people and time for mine area with > 100 ha [7]. It is also used to monitor the areas that affected by acid mine drainage quickly and repeatedly, producing images with high spatial resolution and precise targeting [8]. As for modeling, drones can produce a 3D model of a mining area that shows excellent pit mine and stockpile at an inexpensive cost [9].

The emergence of UAV photogrammetry replaced traditional methods and became a new technology for comprehensive survey in the mine area. However, the above analysis indicates that the application of UAVs in the mine area is still in its infancy, and current studies still focus mainly on 3D reconstruction and topographic survey, followed by geological hazard monitoring and ecological assessment [10].

2. METHODS

The sand mine project of 182,634 m^2 is located in West Bandung Regency, West Java Province, Indonesia (Figure. 1).

Figure 1. Sand mine project location [11].

The stages of drone used implementation are shown in the flow chart (Figure. 2)

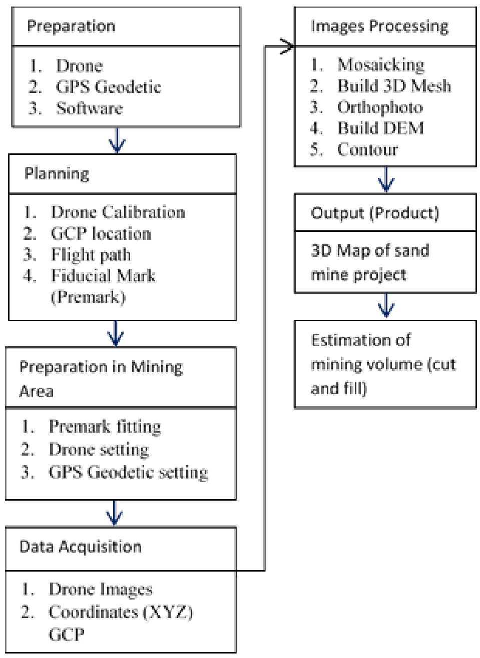

Figure 2. Research methodology.

The types of equipment used are DJI Phantom 4 Pro Drone, Sokkia GCX2 GPS Geodetic, and processing software such as Ctrl PLUS DJI, Pix4d Capture, Agisoft Metashape Professional, ContextCapture, Global Mapper, and Civil 3D. Planning for the number and location distribution of Ground Control Points (GCP) is carried out based on the size and shape of the sand mine area (Figure. 3).

Figure 3. GCP distribution plan [11].

Field preparation includes Premark installation activities, drone settings, and GPS Geodetic settings (Figure 4). 6 GCPs were carried out an observational survey by GPS at the sand mine project site. The distance between one GCP and another GCP is not more than 100m. The aerial shooting was carried out in 3 flying missions with different altitudes for each mission in upright and 90˚ camera positions. This is done because the topography contoured and there were hills. The photo is taken at a height of 65 m using 60% overlap and 40% side lap. After that, 554 photos were obtained by photo-taking and observation surveying with GPS.

Figure 4. Drone and fiducial mark (Premark).

Data processing begins by displaying and reconstructing photographs based on the flight path and the conditions set during the shoot, so an overall photo view is obtained (Figure. 5).

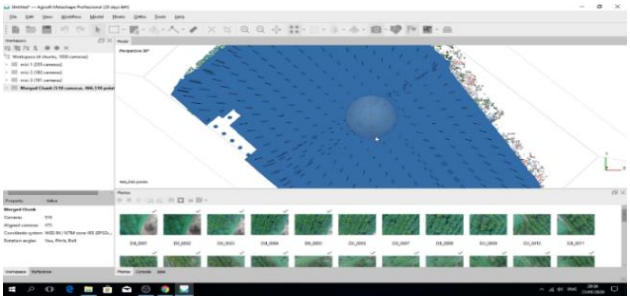

Figure 5. Image alignment.

The 3D mesh build process is carried out to display a 3D model visualization based on the overall photo overlay and actual topographic conditions in the field. 3D Mesh is a structural arrangement of a three-dimensional model consisting of polygon using reference points in the X, Y, and Z axes to define a shape with height, width and depth (Figure. 6).

Figure 6. 3D Mesh.

In order for the 3D model to have high accuracy, GCP input is carried out on the model (Figure. 7).

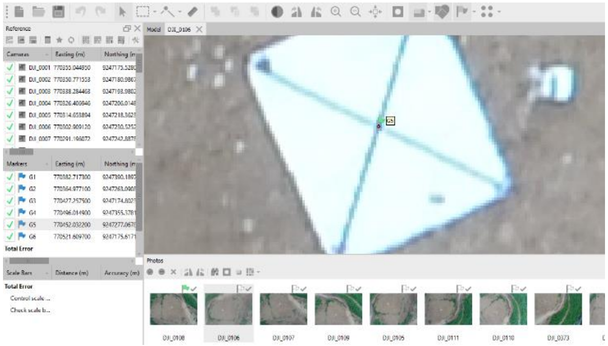

Figure 7. GCP input on the model.

After the GCP input has been completed and has a high degree of accuracy (error $\leq$ 0.5 m), the next process is making of a Digital Elevation Model (DEM). In DEM, there are different colors that indicate the different ground levels (Figure. 8).

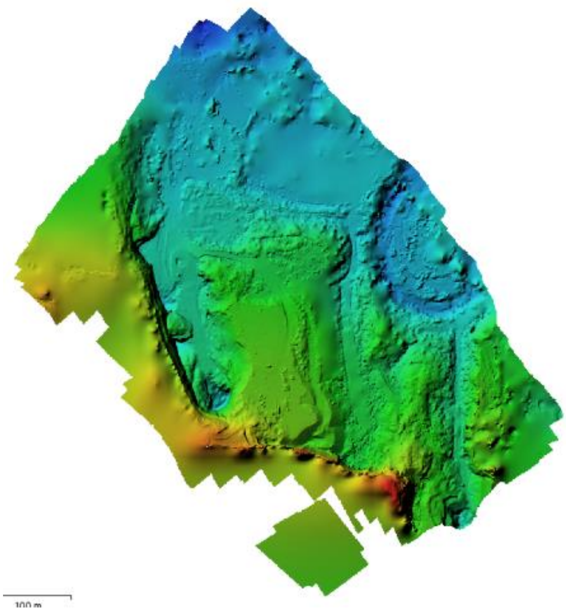

Figure 8. Digital Elevation Model (DEM).

The process is carried out using the orthophoto process, by making a series of vertical or perpendicular aerial photographs into a single unit that has been corrected geometrically so that the scale and orientation of the photos are uniforms (Figure. 9).

Figure 9. Orthophoto.

3. RESULTS AND DISCUSSION

The output of this research is a 3D map of the sand mine project featuring a 3D visualization of the ground level in the mine area, complete with contours, and other supporting information for office buildings, parking areas, and rivers around the mine area (Figure. 10).

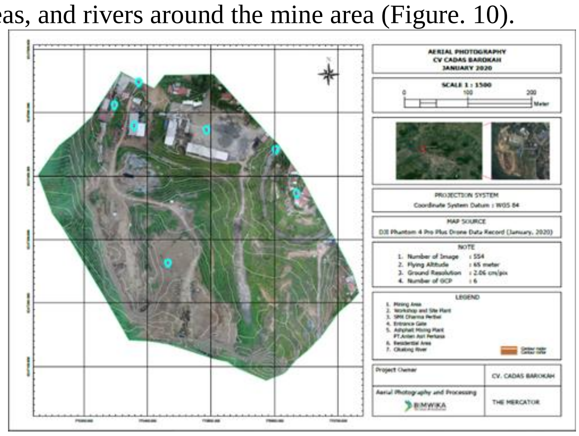

Figure 10. 3D Map of sand mine project

The cut and fill volume calculation was carried out by comparing the height of the ground surface in the sand mining area in 2019 and 2020. Information on the land surface in the mining area in 2019 obtained from the Indonesian Earth Map (RBI) scale 1: 25.000 from the Geospatial Information Agency. The contours then converted (vector to raster) into a 3D model of the land in the form of a Digital Terrain Model (DTM). Meanwhile, the ground surface in the mining area in 2020 is generated from DEM by drone shots which only display the ground level (DTM) excluding surface height (trees, buildings, and other objects).

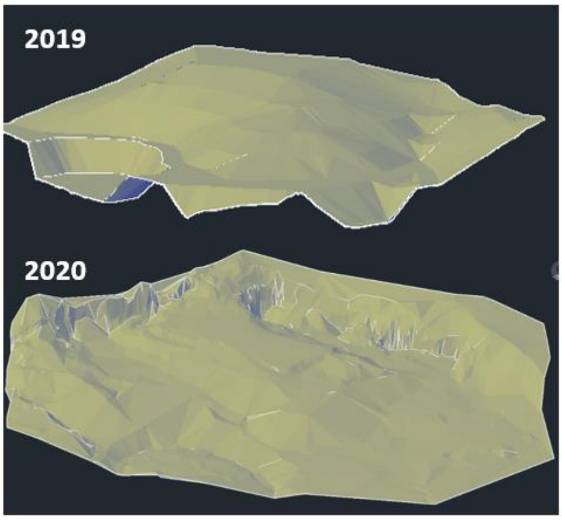

Figure 11. DTM 2019 from topographic map contour and 2020 from drone model.

The 2020 DTM drone shots look more detailed because they are taken from a flying altitude of 65 m above ground level, so they are able to produce large-scale maps compared to the 2019 DTM converted from the RBI Map at a scale of 1: 25.000 from satellite shots. The elevation difference in the mine area can also be displayed through the contours of the 2019 RBI Map with the contours of the 2020 drone shots.

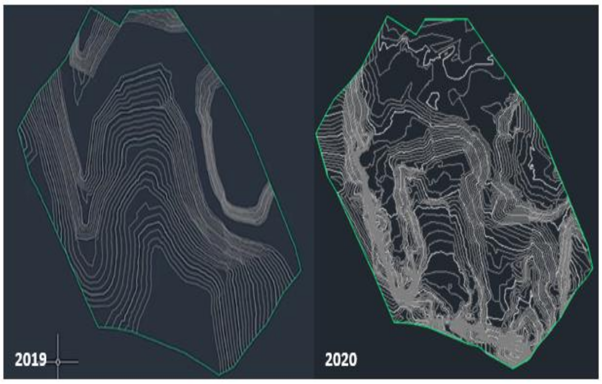

Figure 12. Contour of 2019 from topographic map and 2020 from model.

The contours in 2019 look more regular and have fewer lines than the contours in 2020. This is because the 2019 contours are taken from the RBI map at a scale of 1: 25.000 which has a contour interval of 12.5 m. Whereas the 2020 contour of the drone shots has a larger scale, specifically 1: 1.500 and has a tighter contour interval of 1-2 m.

Calculation of the excavation volume obtained by overlaying the contours of 2019 and 2020 (Figure. 13). Furthermore, the volume of excavation can be seen by looking at the total cut and fill volume (Figure. 14). The volume of excavation obtained is 1.309.681.13 m^3 and the volume of the embankment is 427.626,21 m^3.

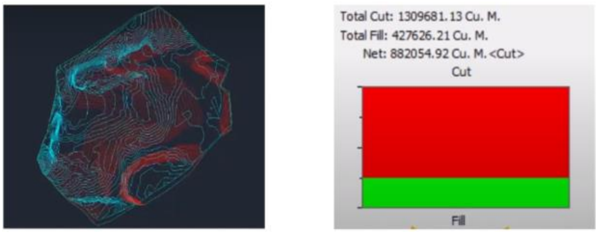

Figure 13. Comparison of existing contour Volume of cut and fill. and RBI.

Comparison of cut and fill volumes in a sand mine project carried out periodically every 2 weeks, 1 month, or 2 months using drones in order to obtain a better and more detailed visualization of land surface changes, also the accurate and continuous cut and fill volume values. This method can be done because drones can be used at any time and the data processing is easier than using satellite image data.

4. CONCLUSION

The use of drone is very effectively applied in project activities, both sand mine projects and other projects that require actual calculations for cut and fill. With this survey method, we can shorten the time in measurement activities compared to conventional methods or terrestrial surveys. In addition to the short duration of time, this method has a better safety factor, because it can cover all areas from areas that have a gentle slope to areas that have high elevation and steep slopes. Infield survey activities using this method can decrease the requirement of manpower, so the possibility of accidents in the field is very small. The accuracy level of the data generated in this survey method is excellent with an accuracy of up to 5-10 mm. Therefore, the costs incurred by this method can be more efficient than using the terrestrial survey method.

For further research, it is necessary to compare the cut and fill volume values using drone with the results of terrestrial survey measurements. Currently, the Total Station tool is still relied on for measuring and calculating cut and fill volumes in sand mine project. Total Station is easy to operate and can automatically calculate cut and fill volumes on the spot in the field. Of course, this is considered an advantage for Total Station if the sand mine area measured is not too large and the required information is sufficient volume value, not in the form of a photo map that describes the existing condition of the sand mine area as better documentation for monitoring and project progress.

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