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ASSESSMENT OF PHOTOGRAMMETRIC DATA OVER CONVENTIONAL SURVEY DATA IN TOPOGRAPHIC MAP AND VOLUME COMPUTATION

A Case Study of TPCPLC Dar es Salaam

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BSc. Geomatics

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ASSESSMENT OF PHOTOGRAMMETRIC DATA OVER CONVENTIONAL SURVEY DATA IN TOPOGRAPHIC MAP AND VOLUME COMPUTATION

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A Dissertation Submitted to The Department of Geospatial Science and Technology in Partial Fulfilment of the Requirement for the Degree of Bachelor of Science in Geomatics (BSc. GM) of the Ardhi University, July 2023.

CERTIFICATION

The undersigned certify that they have proof read and hereby recommend for acceptance by Ardhi University a dissertation titled "**Assessment of Photogrammetric Data over Conventional Data for Topographic Map and Volume Computation**" in partial fulfillment of the requirement for the award of degree of Bachelor of Science in Geomatics of the Ardhi University.

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Dr. Saria, Elifuraha	**Mr. Bakari Mchila**
Supervisor	**Supervisor**
Date………………….	Date……………………

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I, Kweja, Alphayo Phabian hereby declare that the contents of dissertation report are the results of my own study and findings to the best of my knowledge. They have not been presented anywhere else as a dissertation for diploma, degree or any similar academic award in any institution of higher learning.

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Kweja, Alphayo P.

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Date………………………………

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DEDICATION

I dedicate this work to my family Mr. & Mrs. Phabian Kweja Kalando, my brothers and sisters together with all my friends for their support for the completion of my Bachelor Degree.

ABSTRACT

Aerial Photographic survey is one of modern surveying methods. This method uses manned or unmanned aerial vehicles (UAVs) depending on the area to be surveyed. The technology is potential and powerful since is not time consuming, covers large, reaches inaccessible area during surveying and not labor intensive in ground data acquisition for geospatial application. Recently the technology has been used in engineering application, topographic mapping, mining and volume computations. Although the presence of conventional methods of survey such as Total Station which is basically applied in many survey fields. Conventional survey is mostly used in field data collection but it is seen as time consuming and labor intensive. This research assesses the precision and accuracy of the aerial photographic survey and conventional survey method of ground data acquisition in generation of 3D models (Topographic maps) and in volume analysis. The two method of surveying were used to survey two stockpiles of material at TPCPLC. From the remotely operated drone mission the digital terrain model and orthomosaics were produced from the pix4D software.

The generated georeferenced orthomosaics were imported in Global mapper software and the cloud ground point for the stockpiles were extracted as point coordinates. Using a total station, observation for detail picking are measured and recoded as ground positions the stockpiles. The average end area conic approximation method was used to compute volume using the AutoCAD (Civil 3D) software. The computed volume of the two stockpiles was 8339.95m^3 in stockpile 1 for conventional data, 8506.00m^3 in stockpile 1 for photogrammetry data. 1473.11m^3 in stockpile 2 for conventional data and 1575.48m^3 in stockpile 2 for photographic data. The percent difference method was used to analyze the volume results. A smaller deviation of volume was observed in both stockpiles for the two methods which are 1.97% in stockpile 1 and 6.72% volume deviation in stockpile 2. In the 3D model (Topographic map) aerial photographic shows a better resolution than the conventional which is influenced by a smaller ground data interval of 0.3 m to 0.5 m compared to the one used in conventional data of 2 m to 3 m interval. The difference in resolution between the two method aim to show aerial photographic survey method with its capability to provide redundant observation/data which is highly needed in surveying measurements. The Aerial Photographic survey and conventional survey are comparable in volume computation due to smaller volume percent difference. Based on the research conclusion, Aerial Photographic survey

method provides a superior amount of volume and the best 3D model (Topographic map) view than Conventional survey method.

Future efforts should be made on surveying the stockpile of material with same data resolution for both or other terrestrial methods to see the percent difference on Volume computation and Topographic map.

Keywords: Aerial Photographic Survey, Conventional Survey, Stockpile, Topographic map, Volume Computation.

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List of Abbreviation

DEM	Digital Elevation Model
EDM	Electronic Distance Measure
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
LiDAR	Light Detection and Ranging
RPA	Remotely Piloted Aircraft
RTK	Real Time Kinematics
TLS	Terrestrial Laser Scanner
TPC PLC	Tanzania Portland Cement Public Limited Company
TS09	Total Station 09
UAV	Unmanned Aerial Vehicle
USDA	United State Department of Agriculture
UTM	Universal Transverse Mercator
X	Easting
Y	Northing
Z	Elevation

CHAPTER ONE

INTRODUCTION

1.1 Background of Research

In about four-decade land surveying has been advancing in technology for both terrestrial and space methods. This technological advancement has reduced the fieldwork data collection, manpower, time and improved precision in surveying outputs. Recently advancement in aerial photographic survey has revolutionized the use of manned aerial vehicle and the Unmanned Aerial Vehicles (UAV) depending on the size of area to be surveyed (Dewitt et al., 2014). Before the advancement of unmanned and manned aerial vehicles, conventional surveying technique was mostly used in field data collection but it is seen as time consuming and labor intensive. However, there are studies that used the two method in data collection but did not assess the quality and precision of the data and the end products produced by the two methods (John wiley & Sons, 2002). Engineers and surveyors are using UAV however this technology has some problems from data collection to the end products which are geometrical errors in photographs.

For many years in surveying field modern technologies have been developed such as Global Navigation Satellite System (GNSS), Terrestrial Laser Scanner (TLS), digital cameras for Photogrammetry and reflectorless EDM devices. The development of these instruments aims in improving the standard of surveying measurement and standards. Due to different circumstances the development of new instruments has not completely stopped the use of conventional devices in surveying. In less than a decade, the surveying industry introduced Unmanned Aerial Vehicles (UAVs) with photogrammetry capabilities as a survey instrument (Gillins & Dennis, 2022). Through advancement of surveying technologies, surveying industry must keep previous and current technologies by assessing the quality and precision of data acquisition from different survey methods using the technologies available. Accuracy and precision are often compared to previously technologies and practices to determine their scientific validity (Gillins & Dennis, 2022).

Aerial Photographic survey obtains reliable information about physical objects of the environment through the process of recording, measuring, interpreting photographic images and patterns of electromagnetic radiant imagery. Inventions of photography started in 1850 followed by invention of airplanes which are the platform in 1900 and lastly the invention of computers in 1950 which are used for processing and analyzing of analog and digital photographs. One of the popular photogrammetry societies in the world are the American Society of Photogrammetry and Remote Sensing (Colomina & Molina, 2014).

Aerial Photographic surveys establish targeted, and occasionally non-targeted photo control on the ground to relate aerial photographs to a projected horizontal and vertical datums. This method is very useful as it has many advantages. It covers large areas and maps inaccessible areas in spatial observation, not time consuming and easy to be understood.

Although, conventional surveying has been broadly applied in most of the projects such as topographic and volume computations surveys, it faces various challenges in data collection as it requires high manpower, prone to errors and visibility (line of sight) in data acquisition in field surveys. Examples of inaccessible areas like forests, it's impossible to use these methods for collecting terrain data.

Currently there are different aerial techniques for ground data collection that are used for topographic mapping and volume computation. And there are studies/ research on their accuracy over topographic maps and volume computation surveys. Some of these methods are Lidar technique and Remote sensing techniques. Although LiDAR technology is not affordable due to the high costs in LiDAR data collection, how to effectively process the raw LiDAR data and extract useful information remains a big challenge. And because of the specific characteristics of LiDAR data, issues such as the choices of modeling methods, interpolation algorithm, grid size, and data reduction are challenging study topics for the generation of a high-quality DEM from LiDAR data (Zhang et al., 2007).

Remote sensing technique recently is applied in surveying fields for mapping purposes using the satellite imagery that is generated through the platform. However, the Remote sensing data possess an accuracy that is not useful in mapping purposes for volume calculation. The U.S Department of Agriculture's (USDA) stated the Cropland Data Layer from a remote sensing is a 30m resolution land cover map. This was produced annually to assess crops and cropland area across the conterminous United states (Tyler et al., 2021).

A study was conducted on comparative evaluation of excavation volume by terrestrial laser scanning (TLS) and total topography station-based methods at Aksaray University in 2010. In this study the performance of a laser scanning method, robotic total station instrument and geodetic method of volume computation were investigated. The volume computation was carried out using these methods in an excavation area and the methods were compared in terms of accuracy, time and cost. It was concluded that all methods can satisfactorily be used for volume computing, however, the choice of method should be made according to the location and size of area, required accuracy, budget and time frame (Murat et al., 2010).

A study on volume estimation of the 1998 flank collapse at Casita volcano, Nicaragua: A comparison of photogrammetric and conventional techniques. A research conducted in department of geography at University of Cambridge. A precipitation-triggered flank collapse occurred at Casita volcano, Nicaragua, leading to a devastating lahar. The failure volume was calculated using a range of methods. Several pre- and post-failure digital elevation models were created, based on photogrammetric, cartometric and surveying data. The wide range in resulting volumes prompted an assessment of the accuracies and potential problems associated with each of the datasets and techniques used. The best estimate for the failure volume is 106 m^3. It is based on a vegetation-corrected pre-failure DEM, generated using automated digital photogrammetry, and a post-failure surface based on a field survey carried out with a Total Station (John wiley & Sons, 2002).

In contrast to the current research, this study is assessing the end products from the aerial photographic survey and conventional survey methods by examining the produced topographic map and volume computed from two dormant stockpile surveyed. In this assessment the study will also look at the accuracy and precision in data acquisition procedure from aerial photographic survey technique and conventional survey technique. In Figure 1.1 and 1.2 shows photogrammetry methodology for data capture and processing.

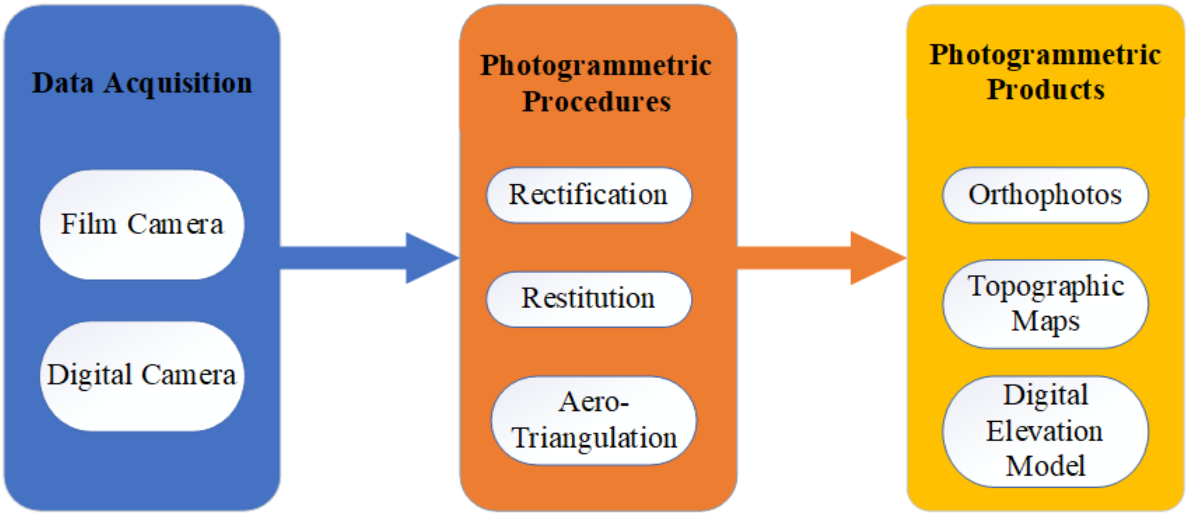

Figure 1.1 Photogrammetry procedures

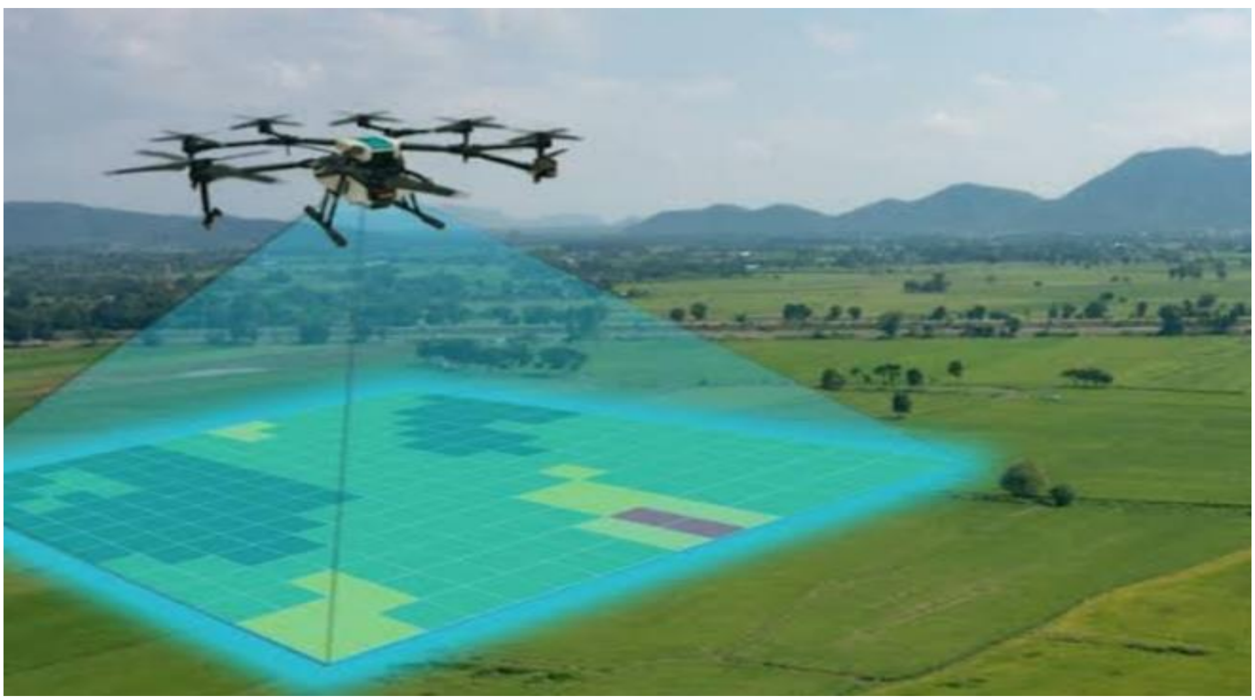

Figure 1.2 Photogrammetry Platform (Thedronegirl.com, 2019)

1.2 Problem Statement

Land surveying has several methods for data collection such as the conventional, terrestrial and space techniques used in construction, engineering and mining. However, Conventional survey is one of the most applied methods for data collection for topographic survey and volume computation using precise instrument like total station. Despite its numerous advantages it has various challenges such as time-consuming, labor-intensive and has low resolution in terms of data collection for topographic and volume computation survey. For aerial photographic survey it is a terrestrial method which use manned aerial vehicle and unmanned aerial vehicle that are groundless contact to provide useful data for land surveying which is accurate and precise. It is less time-consuming, cost-effective, collects data with high resolution and high accurate in the field. In Tanzania conventional survey method is highly used in data collection for different surveying purposes. But due to world technological advancement, photogrammetric surveying method is capable to collect precise land surveying data to generate topographic map and volume outputs. Due to this, there is a need to assess the end product of the two methods in terms of topographic mapping and volume computations to come up with the best method that can be relied in surveying field for accurate data collection for volume and topographic surveying in Tanzania. This research aims to assess the outputs of topographic mapping and volume computation from the data collected using aerial photographic and conventional surveying method.

1.3 Objectives of Research

1.3.1 Main Objective

The main objective of this research is to assess efficiency and suitability of aerial photogrammetric survey methods and the conventional survey method in data collection for topographic mapping and volume computation on different surveyed surfaces.

1.3.2 Specific Objectives

1. To assess the volume computed using photogrammetry image data over conventional instrument data of the surveyed terrain.
2. To assess photogrammetry image data over conventional data suitability in topographic mapping on a surface terrain.
3. To assess volume computation of photogrammetry and conventional data for surveyed terrain using a provided designed final level.

1.4 Description of the Study Area

The selected study area is the Tanzania Portland Cement Public Limited Company (TPCPLC) located at Wazo Hill, Tegeta Dar es Salaam shown below in Figure 1.3. The survey is of the stockpile of material for production of cement at the Twiga Cement industry.

Figure 1.3 TPCPLC Twiga Cement industry (TPCPLC, 2023)

1.5 The significance of the research

This research is expected to provide valuable insights into the accuracy, efficiency and suitability of aerial photographic survey data over the conventional survey data for topographic mapping and volume computation. The findings from this research is useful for professionals in various fields such as construction, engineering, geology and environmental management who require reliable and cost-effective methods for data collection. In addition, the recommendation of this research to the field contributes to the advancement of the use of aerial photographic surveys for topographic mapping and volume computation in Tanzania.

1.6 Beneficiaries of the Research

The research benefits surveyors and engineers as the major professionals involved in surveying and engineering works as it shows an alternative method for mapping and volume computation surveys. The project owners and the project assessor also benefit from the results of this research as the addition of using a new method which is cost-effective and will help to shorten the duration of project and start new projects. Mines is one of the areas where data collection for mapping and volume computation is a day to day activity, this research illustrate the best method for volume estimations and topographic mapping.

1.7 Scope and Limitations.

This research is limited and basically focused with the terrain data that will be surveyed from the two methods of ground data collection on the stockpile of material at Twiga Cement industry (TPCPLC).

1.8 Chapter Summary

This thesis consists of five chapters, arranged systematically to accomplish the preparation and presentation of the research study "Assessment of Photogrammetric Data over Conventional Data for Topographic Map and Volume Computation".

Chapter one, introduces the research by describing relevant background information, the related studies conducted by other scholars, statement of the problem, objectives, significance, scope and limitation and beneficiaries of this study. Chapter two, presents the literature review of the research study, the methodologies adopted in previous researches and approaches taken to reach their objectives and summarizes briefly the difference between this study "Assessment of Photogrammetric Data over Conventional Data for Topographic Map and Volume Computation" and other studies and what is the expected outcome in comparison to other studies. Chapter three, describes the techniques and methods involved throughout the research in collection of data and in carrying out the research. It also describes some of the software that will be used in order to reach the expected output. Chapter four, presents the results and analysis that clarify the findings of the research objectives. Chapter five, it includes conclusions derived from the results and discussion of the findings. It includes recommendations for further studies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Concept of Photogrammetry

Photogrammetry has been defined by the American Society for Photogrammetry and Remote Sensing as the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena as shown in Figure 2.1. As implied by its name, the science originally consisted of analysing photographs, however the use of film cameras has greatly diminished in favour of digital sensors. Photogrammetry has expanded to include analysis of other records, such as digital imagery, radiated acoustical energy patterns, laser ranging measurements, and magnetic phenomena (Wolf et al., 2014).

Developments leading to the present-day science of photogrammetry occurred long before the invention of photography. As early as 350 B.C. Aristotle had referred to the process of projecting images optically. In the early 18th century Dr. Brook Taylor published his treatise on linear perspective, and soon afterward, J. H. Lambert suggested that the principles of perspective could be used in preparing maps (Wolf et al., 2014).

Figure 2.1 Photography sample data (Google, 2022)

Topographic mapping using photogrammetry was introduced to North America in 1886 by Captain Eduard Deville, the Surveyor General of Canada. He found Laussedat's principles extremely convenient for mapping the rugged mountains of western Canada. The U.S. Coast and Geodetic Survey (now the National Geodetic Survey) adopted photogrammetry in 1894 for mapping along the border between Canada and the Alaska Territory. The role of photogrammetry in mapping applications image acquisition and image measurements. Mathematical relationship between image and objects space, direct and inverse problems of projective and similarity coordinates transformation (Wolf et al., 2014). Figure 2.2 explain the development of photogrammetry from 1850 to present.

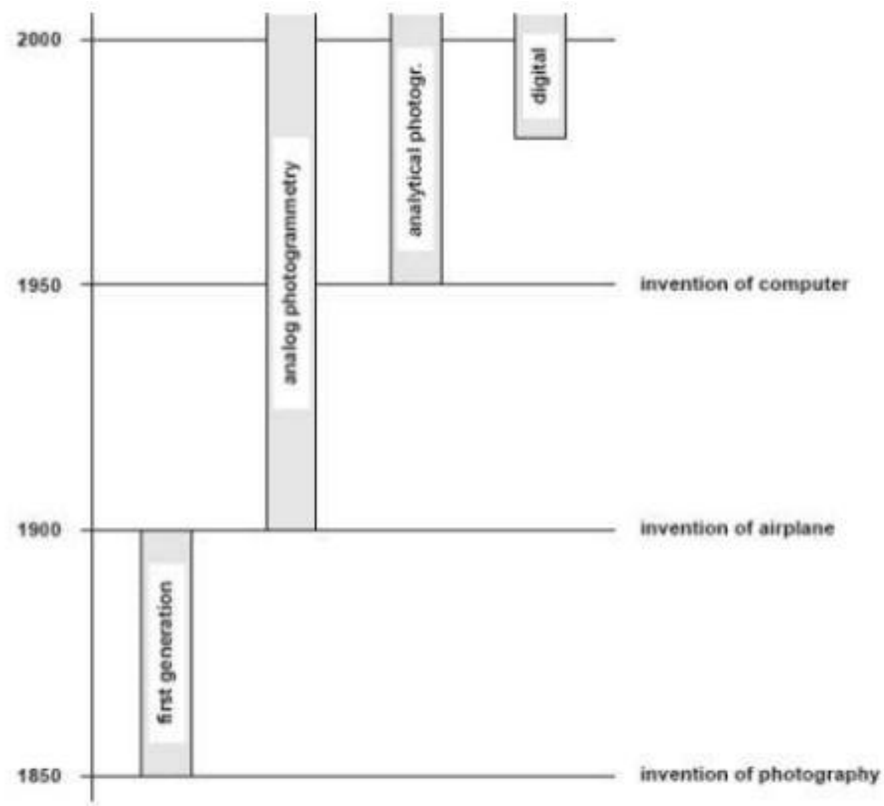

Figure 2.2 Chart showing development of Photogrammetry technology (Dewitt et al., 2014)

2.1.1 Photo Controls

Ground control points (GCPs) are points on the earth's surface of known location used for geo-referencing, and are the cornerstone that makes the highest accuracy mapping possible. With sleek coloring, well-laid shading and realistic 3D modeling in photogrammetry, GCPs are the tool used to bring the photogrammetry project to a precise absolute position (X, Y, Z) and scale (Ramirez et al., 2016).

Photo control needs to be established on the stable ground, and should be painted with color to be visible enough at the time of geo-referencing. Before a photogrammetry survey the GCPs should be surveyed by using GPS or Total station to have their position and elevation which are used in geo-referencing and photo processing. Figure 2.3 show a photo control for aerial surveys.

Figure 2.3 Ground control points for Photogrammetry survey (Ramirez et al., 2016)

2.1.2 Photo Mosaic

Photomosaic is a technique which transforms an input image into a rectangular grid of thumbnail images preserving the overall appearance. The typical photomosaic algorithm searches from a large database of images one picture that approximates a block of pixels in the main image (Biggs & Hunkin, 2005).

Since the quality of the output depends on the size of the database, it turns out that the bottleneck in each photomosaic algorithm is the searching process (Blasi & Petralia, 2022). Mosaic is an assembly of photographs technically matched such that they form a single continuous photographic image. There are two types of mosaic in photography surveying;

i. Uncontrolled Mosaic is the technique that is one simply made by matching the photographs by details only.
ii. Controlled Mosaic is the technique that is one which before being laid, the individual photographs are either stretched or squeezed to fit predetermined locations of control points and at the same time match the details. A controlled mosaic is more accurate than an uncontrolled one.

2.1.3 Photogrammetry Elements

Photogrammetry uses photographs to create precise measurement of 3D objects and environment. The following are some of the key elements of photogrammetry.

1. Cameras, high-quality cameras are required to capture high-resolution images with accurate color and exposure.
2. Control points are on the stable object or environment being scanned that serve as reference points for the photogrammetry software to accurately align the images.
3. Image acquisition, the photographs need to be taken from different angles and positions to capture the entire object for the environment.
4. Image processing software, photogrammetry software processes the images, aligns them and creates a 3D model of point cloud.
5. Mesh, the point cloud can be converted into a mesh, which is a surface made up of interconnected polygons. The mesh can be texture with original photographs to create a realistic representation of the object or environment.
6. Point cloud, is a set of points in 3D space that represent the object or environment being scanned. Each point in the cloud corresponds to a point in one of the images taken.
7. Accuracy assessment, it’s very important to assess the accuracy of the photogrammetry result to ensure they meet the desired level of precision.

This may be done through comparing the photogrammetry results to ground truth measurement, or by using control points to assess the accuracy of the alignment and measurements (Paine & Kiser, 2012).

2.1.4 Survey Application of Photogrammetry

There are several practical applications of Photogrammetry in surveying, industrial and scientific uses;

For Surveying applications

1. Topographic mapping. Plotting a map detail and contours is normally done using aerial photogrammetry methods. Using the original survey and revision, the technique needs a number of ground survey control points, but it is continually reduced with the improvement of aerial triangulation technique to provide supplementary control (Paine & Kiser, 2012).
2. Large scale plans. Survey may be produced quickly and accurately by air survey method but needs more field check in the provision of ground control. It is applied in large tasks such as road building, major construction and profiles for determination of earthwork quantities (McGlone, 2013).
3. Cadastral plan. Air survey method is applied in the production of cadastral map, through relating the aerial land view and the traditional ground method of cadastral surveying. Where boundaries for land parcels and valuable land features are related.
4. Land uses maps. Air survey is not only used to define the extent of an area, but also measure the yield of a crop. Forestry is a typical application where by plotting the limits of timber and measuring tree heights, an accurate estimate of yield may be given.
5. Hydrographic maps and charts. Air surveys are particularly valuable in the accurate plotting of coastlines, sandbanks and small islands where the changing tide is a problem for ground methods (McGlone, 2013).
6. Exploration and reconnaissance. Information may be gained about areas to which access is restricted by employing air survey techniques.

For industrial and scientific application.

1. Detailed survey of historic buildings. Precise plans of building facades and architectural detail may be obtained without direct measurement by terrestrial photogrammetry techniques.
2. Traffic accidents. Terrestrial method is applied for accident detail record, this allows obstruction to be cleared without delay. The scene being plotted at a later stage.
3. Medical applications. Short range photogrammetry is used by doctors in dentist investigation, defining conditions and treatments.
4. Analysis of movements. Tidal and particle movements may be analyzed by photogrammetry techniques by taking photographs of moving surfaces with a fixed camera.

2.1.5 Photogrammetry Platforms and Software

Photogrammetry platforms are software tools that are used to process and analyze photographs to generate 3D models, point clouds and other geospatial data. These platforms use algorithms to analyze overlapping photographs taken from different angles and distances, and reconstruct the objects or landscape they depict (Paine & Kiser, 2012). There are several photogrammetry platforms as shown below;

1. Agisoft Metashape, a professional photogrammetry software that is widely used for creating 3D models, point clouds and orthomosaics.
2. Pix4D, a cloud-based platform for processing aerial imagery that is used in a range of industries, including surveying, agriculture and construction.
3. OpenDroneMap, an open source photogrammetry platform that can be used to process aerial imagery captured by drones.
4. Autodesk ReCap, a software tool for creating 3D models and point clouds from photographs, which is widely used in the architecture, engineering and construction industries.
5. RealityCapture, a photogrammetry software that can create high 3D models, texture 3D meshes and point clouds.

2.2 Concept of Conventional Survey

Surveying has been an essential element in the development of the human environment for so many centuries. It is an essential requirement in the planning and execution of every form of construction. Surveying was essential in the fields of transportation, construction, building, apportionment of land, and details mapping. Total station surveying is defined as the use of electronic surveying equipment used to perform horizontal and vertical measurement in reference to a grid system (Wolf & Ghilani, 2005). A total station integrates the function of electronic theodolite for measuring angles, and an EDM for measuring distance.

The total station simplified the procedure of traversing by integrating the EDM into the theodolite and reading all measurements digitally. The introduction of satellite positioning systems has provided surveyors with an additional measurement technology to perform survey tasks. Although RTK GPS is now widely used, there are still many surveyors who do not benefit from GPS technology because of a perception of complexity and expense. Integrated GPS and total station system significantly, are easy to use and provide a cost-effective entry point to GPS technology (Ghilani, 2017).

2.2.1 Types of Conventional Survey

These are traditional method and instrument used in surveying measurement for field data collection, and are namely below;

i. Chain/Tape survey, is a traditional survey method/instrument which is used for distance measurements in field data collection. This method is used on a small-scale surveying project (Wolf & Ghilani, 2005).
ii. Total station (Theodolite and EDM), an ordinary survey instrument used for angle, distance measurement (Traversing) and detail surveying (X, Y, Z) for field data collection (Wolf & Ghilani, 2005).
iii. Levelling, is a traditional method using level instruments and levelling staff for elevation determination on the earth surface. This is important for construction projects where accurate elevation measurements are necessary (Wolf & Ghilani, 2005).

2.2.2 Limitations of Conventional Survey Method

1. Time consuming. Some conventional methods of surveying are time consuming especially working for large areas or complex sites. Surveyors must physically travel to site and manually take measurements which can be slow and need more resources.
2. Limited accuracy. Conventional surveying methods have limitations on accuracy. Error may occur due to human error, instrument error and environmental factors such as weather conditions.
3. Costly. Using conventional methods may be costly when surveying large projects that require extensive surveying. This is because surveyors and other specialized expertise should be paid and purchasing and maintaining the required equipment.
4. Limited data. Conventional methods may not provide a complete picture of the site or structure being surveyed. Examples using conventional method detail are picked up to 5m intervals.
5. Difficult to update. Using conventional survey methods is difficult to update as changes occur to the site or structure. This makes it a challenge to keep survey data up-to-date and accurate over time.
6. Safety risks. Conventional surveying methods may involve physical hazards, such as working at heights, working in confined space or exposure to hazardous material. Example in mine sites.
7. Limited access. Conventional surveying methods may be limited by terrain, weather conditions or other factors that make it difficult or impossible for surveyors to access the site.

2.3 Detail Topographic map

Topographic survey is a survey that gathers data about the elevation of points on a piece of land and presents them as contour lines on a plot. The purpose of a topographic survey is to collect survey data about the natural and man-made features of the land, as well as its elevations. Topographic maps are used to show elevations and grading features for architects, engineers, and building contractors (Kimerling et al., 2016). It involves determining the relative locations of points (places) on the earth's surface by measuring horizontal distances, differences in elevation and directions.

Topographic maps give the locations of places (observable features); they usually serve as base maps. Topographic surveying has potential in producing topographic maps, constructing topographic (cross sectional) profiles, establishing vertical and horizontal control for accurately defining locations.

Topographic survey involves determination of crucial data to be used in preparations for alignment, grading and earthwork quantities for construction purposes. The geospatial information acquired supply important details for a particular engineering project to be undertaken mostly in part of designing (Kimerling et al., 2016). Detail topographic surveying comprises all survey operations required for design and Construction of engineering works such as highways, pipelines, canals, or Railroads. It involves:

i. Reconnaissance and planning
ii. Works design
iii. Right of way acquisition and Construction of works

2.4 Importance of Accurate Volume Computation

1. In construction, accurate volume computation is essential for determining the amount of earthwork that needs to be excavated or filled to ensure the site is properly graded and prepared for construction. Helps contractors to avoid over or underestimating of material amount, which can affect project timeline and budgets.
2. In mining operations, accurate volume computation is crucial for determining the amount of material extracted from the earth. This information is used to calculate production rates, plan for future operations and ensure compliance with environmental regulations.
3. Transportation route survey. In route surveying for transportation volume computation is important for designing and maintaining highways, railways and other infrastructure construction. It can help engineers to determine the amount of material needed and how to control the construction based on layers.
4. Environmental management, accurate volume computation is critical for managing natural resources and protecting the environment. Example determination of volume of water in reservoir, which is important for planning and controlling droughts.

5. Agriculture, accurate volume computation is important for determining the amount of fertilizer, water and other inputs which helps farmers to optimize their planting and harvesting schedule.

2.4.1 Advantages and Dis-advantages of Photogrammetry for Volume Computation

Advantages of Photogrammetry in Volume Computation

i. It covers a large area of interest during surveying for volume estimation.
ii. Less time consuming/fast in detail picking necessary for volume determination. Example in dam's construction projects.
iii. Photogrammetry technology is cheap/cost-effective for large areas and in the long run.
iv. Through air survey methods (photogrammetry) we can reach and map inaccessible and restricted areas.
v. Easy to interpret and understand since it uses various software for processing and output production that are used widely by surveyors and engineers.

Dis-advantages of Photogrammetry in Volume Computation

i. Costly at time of installation as it requires a number of ground control points before air survey over an area.
ii. Lengthy administrative procedure for getting permission to fly, this may delay data collection procedure for the survey.
iii. Heavy and sophisticated equipment needed.
iv. Complex system, highly trained human resource needed.
v. It's a weather dependent technology.

2.5 Previous Studies

In October 1998 a precipitation-triggered flank collapse occurred at Casita volcano, Nicaragua, leading to a devastating lahar. The failure volume was calculated using a range of methods. Several pre- and post-failure digital elevation models (DEMs) were created, based on photogrammetric, cartometric and surveying data. The wide range in resulting volumes prompted an assessment of the accuracies and potential problems associated with each of the datasets and techniques used.

The best estimate for the failure volume is 106 m^3. It is based on a vegetation-corrected pre-failure DEM, generated using automated digital photogrammetry, and a post-failure surface based on a field survey carried out with a Total Station. The volume figure is approximately an order of magnitude higher than values reported in previous publications, all of which are based solely on field estimates. This demonstrates that values reported in the literature, if they are not based on rigorous quantitative analysis, must be regarded with caution (John wiley & Sons, 2002).

Volume values are used in many engineering studies, such as road projects, mining enterprises, geological work and building application. A volume can be computed by geodetic, trapezoidal and improved methods such as Simpson-based, cubic spline and cubic Hermite formula. These improved methods model the object surface as nonlinear profile. As the associated technology has developed then so have the opportunities for the development of new techniques in surface modelling. Now, the generation of 3D model is generally achieved by non-contact systems based on light waves and can be completed on a computer. This is particularly useful in situations where there are risks attached to reaching the location to be modelled. The calculations can be performed from a photograph or from scanned images of the object. In this study the performance of a laser scanning method, robotic total station instrument and geodetic method of volume computation were investigated. The volume computation was carried out using these methods in an excavation area and the methods were compared in terms of accuracy, time and cost. It was concluded that all methods can satisfactorily be used for volume computing, however, the choice of method should be made according to the location and size of area, required accuracy, budget and time frame (Murat et al., 2010).

A case study investigating the use of 3D laser scanning and global position system (GPS) to acquire land slide data and to compute earthwork volume. 3D laser scanning, which is just samples the earth's surface in some fixed pattern, is not capable of pointing to particular objects or object features directly in exact global orientation. To obtain global geographic coordinates, a GPS is introduced for use. This study including a brief description of the technology, the measurement method, the operation and the results of the case study is presented. Compared to conventional methods such as triangulation, field and office time of operation was reduced using laser scanning and GPS. Applications where safety may be an issue, such as providing accurate measurements on a landslide or debris flow area, will benefit the most from the strength of this technology (Teng & Du, 2007).

In contrast with the previous studies, this study is assessing the end products from the aerial photographic survey and conventional survey methods by examining the produced topographic map and volume computed from two dormant stockpile surveyed. In this assessment the study will also look at the accuracy and precision in data acquisition procedure from Aerial Photographic survey technique and Conventional survey technique.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter includes the methodological options available and necessary to be used and reasoning behind choosing the best approach for this research. Description of study area, reconnaissance, data search, data collection and research data analysis on conventional and photogrammetry that will be used to achieve the research objectives.

3.2 Description of Study Area

The selected study area is the Tanzania Portland Cement Public Limited Company (TPCPLC) located at (**latitude 6° 40´ 02´´S** and **longitude 39° 10´ 21´´E**) Wazo Hill, Tegeta Dar es Salaam as shown in Figure 3.1 below.

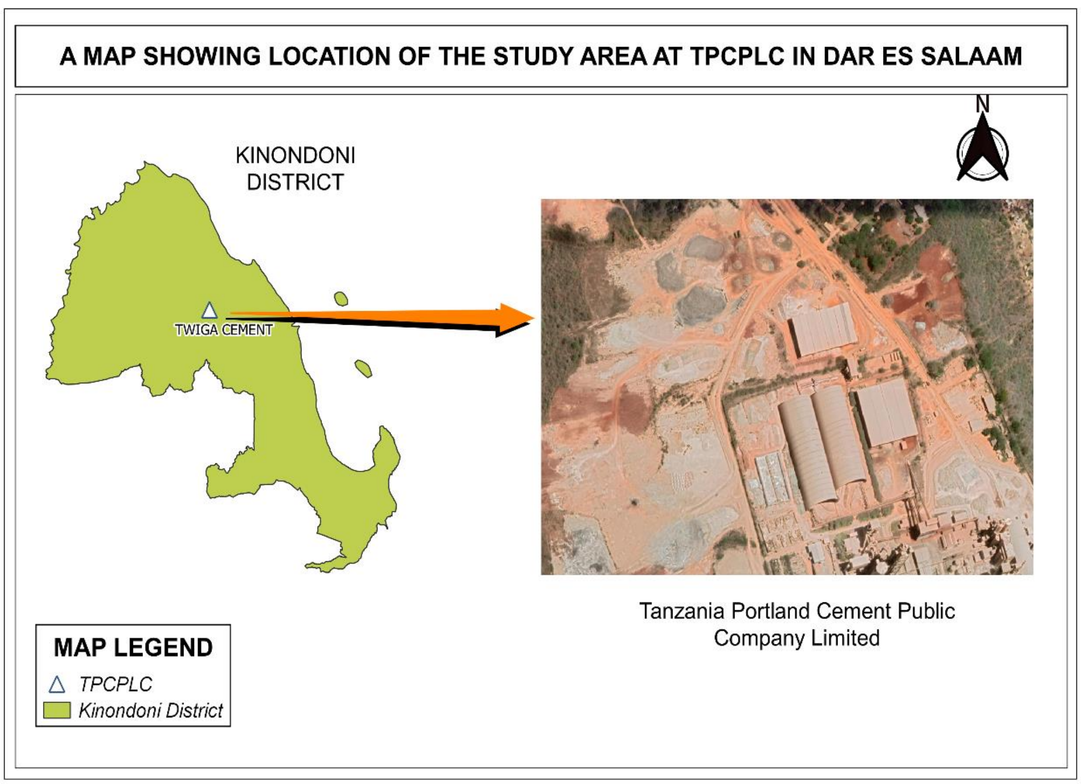

Figure 3.1 Location Map of Study Area

The survey on a number of the dormant stoke piles of material for production of cement at the TPCPLC. Basing on conventional methods using total station to pick detail, and using drone to collect photographs containing spatial details for assessing the output from the two methods that are topographic map and volume of material of the dormant stockpiles. The Figure 3.2 shows a number of stockpiles surveyed at TPCPLC.

Figure 3.2 Photography data at TPCPLC

3.2.1 Reconnaissance

The first thing is field reconnaissance for assessing the nature of area around the number of dormant stockpiles at Wazo Hill and checking the availability of ground control point and photo control point (GCP's) that will be useful in data acquisition for conventional survey and photogrammetry for measurement. The ground control points are well distributed around the site and visible to one another.

3.2.2 Survey Equipment and Instruments

Equipment, tools and materials for field execution and data collection are;

i. Electronic total station (TSO9)
ii. Tripod stand
iii. Kinpoles
iv. Kinpole stand
v. Prisms
vi. Tape measure
vii. Flying Drone and Paint color

3.2.3 Data Search and Control Quality Check

Data quality is checked throughout the process in order to ensure that the best possible output is achieved. Some of control points used for site work are WHC04, WHC05 and BP 1050 located at kizunga, their reference ellipsoid and datum is WGS84 37S zone. Tables 3.1 and 3.2 shows the coordinates of control points and datum check computations.

Table 3.1 Coordinates Points List

POINT ID	NORTHING(m)	EASTING(m)	ELEVATION(m)
WHC04	9263918.143	518062.071	108.701
WHC05	9263817.323	518035.288	107.650
BP 1050	9263907.218	518073.363	107.910

Table 3.2 Measured Coordinates List

POINT ID	NORTHING(m)	EASTING(m)	ELEVATION(m)
WHC04	9263918.149	518062.076	108.701
WHC05	9263817.329	518035.293	107.653
BP 1050	9263907.224	518073.368	107.907

Table 3.3 Datum Check for Total station

Points Name	**Measured Distance (m)**	**Computed Distance (m)**	**Difference in Distance (m)**
WHC04/WHC05	104.316	104.404	0.088
WHC04/BP 1050	15.712	15.712	0.000

3.3 Data Collection by Aerial Photographic Survey

The methodology employed for the aerial topographical survey and mapping is principally divided into two parts, that are Control Survey and Aerial Mapping. The details of each of them are discussed respectively.

3.3.1 Control Survey

Control surveys establish precise horizontal and vertical positions of reference monuments and they serve as the basis for originating or checking subordinate surveys for projects such as topographic surveys. A set of temporary/permanent survey beacons used for referencing will be positioned in an area of interest. Coordinates of these beacons will be provided in appropriate UTM zones of an area. In order to complete validation, a Global Navigation Satellite Systems (GNSS) receiver base is setup at one of the provided beacons then observations are done at other known beacons using the rover in Real Time Kinematics (RTK) Mode in order to check against the known beacon to ensure there is no misclosure. Upon verification of good controls, several temporary ground control points (GCPs) were placed uniformly distributed around the target area. They are also observed in RTK mode using the same GNSS system with the providing reference coordinates as shown in the Table 3.4 and in the Figure 3.3 shows a temporary GCP.

Figure 3.3 Temporary established GCP

Table 3.4: GCPs Coordinates

Point Name	Eastings (m)	Northings (m)	Elevations (m)
GCP01	518438.514	9264280.070	111.423
GCP02	517863.182	9264608.140	98.228
GCP03	517749.718	9265007.260	94.445
GCP04	517377.809	9264759.170	99.124
GCP05	517823.610	9264233.700	103.000
GCP06	518132.976	9263713.250	112.747

3.3.2 Aerial Mapping

Upon completion of the control survey, aerial mapping is carried out by flying the Remotely Piloted Aircraft (RPA). The main activity of aerial mapping is to capture a mosaic of overlapping imagery from nadir using **Remotely Piloted Aircraft (RPA)** that is capable of flying for up to 3 hours per mission. The RPA is equipped with a high-resolution digital RGB sensor, GPS, Compass, IMU and several other navigational components. Figure 3.4 below shows the RPA used for aerial survey.

Figure 3.4 RPA ready for data collection

3.3.3 Aerial Mapping Methodology

Photogrammetry, a scientific method that uses two dimensional (2D) images/photographs to provide measurement data, is the method used for aerial mapping. In addition, Structure-from-motion (SfM) refers to a set of algorithms from computer vision sciences that assist photogrammetry by automatically detecting and matching features across multiple images, then triangulating positions to form 3D point clouds. Images are typically taken from nadir (looking vertically down as crawl flies) while observing a reasonable front and side overlap to ensure all details are captured without gap.

3.4 Aerial Data Processing

Aerial images were downloaded to a computer for processing. Using Pix4D software, the aerial images are imported and the software automatically detect the overlapping area and uses the information to create 3D point cloud. The software performs initial processing which involves calibrating the camera parameters and matching the common point in the images, the step is crucial for accurately reconstructing the 3D scene. Based on the matched points Pix4D creates a dense point cloud representing the 3D structure of aerial images with their respective coordinates (X, Y, Z). Pix4D generates the two 3D models that are digital terrain model (bare-earth surface) and digital surface model (buildings and vegetation). From the two-3D model Pix4D creates an orthomosaic image which is a high-resolution, georeferenced image that has been orthorectified to eliminate distortions caused by terrain variations. Georeferencing involves assigning geographic coordinates (latitude and longitudes) to the orthomosaic photo so that it aligns accurately with real-world coordinates. The original colors from aerial images are applied to 3D point cloud to create visual realistic representation of terrain in the final orthomosaic. Dense point cloud of orthomosaic image generated from material stockpile surveyed at TPCPLC is shown in Figure 3.5 below.

Figure 3.5 Photography data with cloud points

3.5 Data Collection by Conventional Survey

Conventional survey data were collected using a total station (TS09) and reflector prisms. The total station was set up on one of the control points and all necessary adjustments were done to bring the instrument to its appropriate working condition for observation. Observations were done by measuring spot heights and recording using total station and the point intervals were approximately 2m to 3m depending on the terrain change from the bottom to the top of material stockpile. The obtained ground point (Spot heights) of material stockpile were observed in dormant stockpile 1 and stockpile 2. Throughout the survey heights of instruments and targets were maintained to avoid any error due to height changes. Detail survey of material stockpile at TPCPLC is shown in the Figure 3.6.

Figure 3.6 Observation using Total station

3.6 Post Processing of Outputs

From the data collected using the two methods, the volume of material stockpiles were calculated in such that the first step was to produce point cloud coordinates from the orthomosaics image using Global Mapper version (GM 22.1). Then the point clouds data were inserted into Suffer 16 to draw topographic map, for volume computation AutoCAD Civil 3D was used basing on the average end area conic approximation expressed in mathematical model equation (3.1) to compute volume by creating TIN surface base and comparison surface. The second step involved the data obtained from conventional method to draw topographic map and volume computation using the same software as photogrammetric method. After the volume computation for both photogrammetric and conventional method, the volume reports were obtained and hence compared using Percent difference equation to achieve the objective of the study. Equation (3.1) and (3.2) shows the average end area conic approximation mathematical modal and Percent difference equation used for volume computation and volume comparison in AutoCAD Civil 3D

The average end area conic approximation mathematical equation;

$$V = h/3\ (A_1 + A_2 + (\sqrt{A_1 \times A_2})) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

V is the volume of the two section areas

h is height between the created surface

A_1 is the area of created surface

A_2 is the area of the base surface

A_2 is the area of the base surface

Percent difference mathematical equation;

$$\text{Percent difference} = ((\text{Volume1} - \text{Volume2}))/\ ((\text{Volume1} + \text{Volume2})/2)) * 100 \quad \ldots\ldots\ldots. \quad (3.2)$$

Volume1 is the conventional method volume

Volume2 is the photogrammetry method volume

Tin surface was created based on the layer of materials, each stockpile with base layer identified and the upper laying material layer, hence each stockpile tin surface was drawn using data of the respectively survey method. Figure 3.7 up to 3.10 shows the material stockpile tin surfaces.

Figure 3.7 Tin surface for Stockpile 1 Conventional method

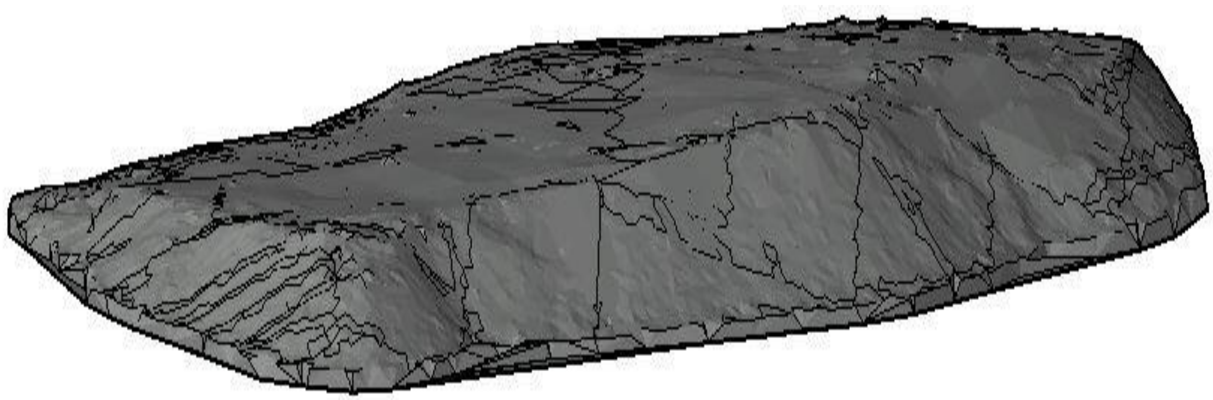

Figure 3.8 Tin surface of Stockpile 1 Photogrammetry method

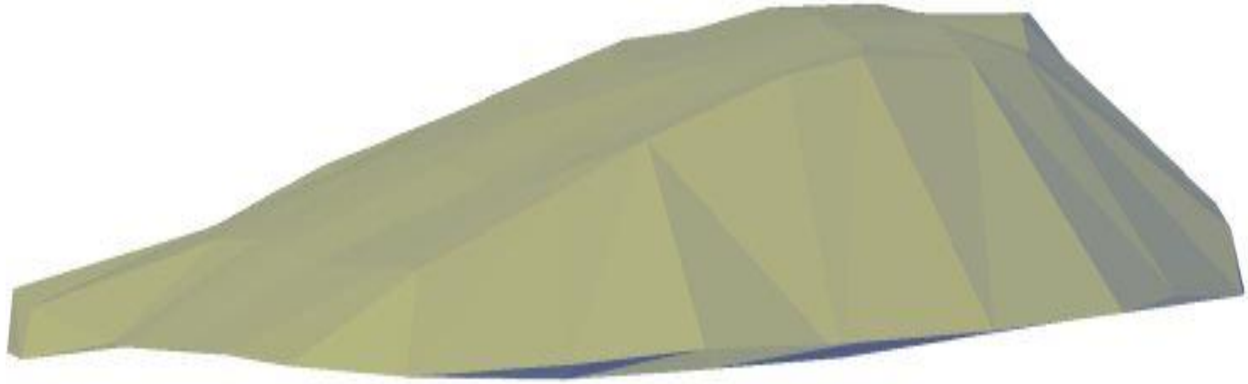

Figure 3.9 Tin surface of Stockpile 2 Conventional method

Figure 3.10 Tin surface of Stockpile 2 Photogrammetry method

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Overview

This chapter includes all results and analysis of the findings gathered in the methodology chapter of the research. And from processing activity the results obtained are going to be assessed on differences and accuracy for the method applied in the research.

4.2 Volumetric Analysis Report

After volumetric calculation using AutoCAD Civil 3D and the layer/surface defined in both data of aerial survey and conventional survey. The software volumetric report for each stockpile are as shown in Tables 4.1 and 4.2 below;

Table 4.1 Volume Computation for Stockpile 1

Object	**Volume of TS(m^3)**	**Volume of Photogrammetry(m^3)**	**Absolute Error(m^3) ±**
Stockpile 1	8339.95	8506.00	166.05

Table 4.2 Volume Computation for Stockpile 2

Object	**Volume of TS(m^3)**	**Volume of Photogrammetry(m^3)**	**Absolute Error(m^3) ±**
Stockpile 2	1473.11	1575.48	102.37

4.3 Volumetric Comparison

The results from measurement and volume estimation from the two stockpiles of material at TPC PLC industry meet various levels of variations which may be due to method of data collection and unseen circumstances. Through the method of percent difference, we can calculate the percent difference between the two volumes for photogrammetry data and conventional data shown in Table 4.3.

Table 4.3 Volumetric Results Analysis

Object	**Volume1 (m^3)**	**Volume2 (m^3)**	**Percent difference (%)**
Stockpile1	8339.95	8506.00	1.97
Stockpile2	1473.11	1575.48	6.72

4.4 Topographic Mapping Assessment (3D Model)

In Topographic mapping outputs are Figure 4.1- Figure 4.4 produced from the stockpile one and two, the resulting topographic maps have different resolution due to the amount of data collected and ground point interval as they differ from conventional which was 2m to 3m and photogrammetry which was 0.3m to 0.5m which is influenced with ability to collect redundant data for mapping.

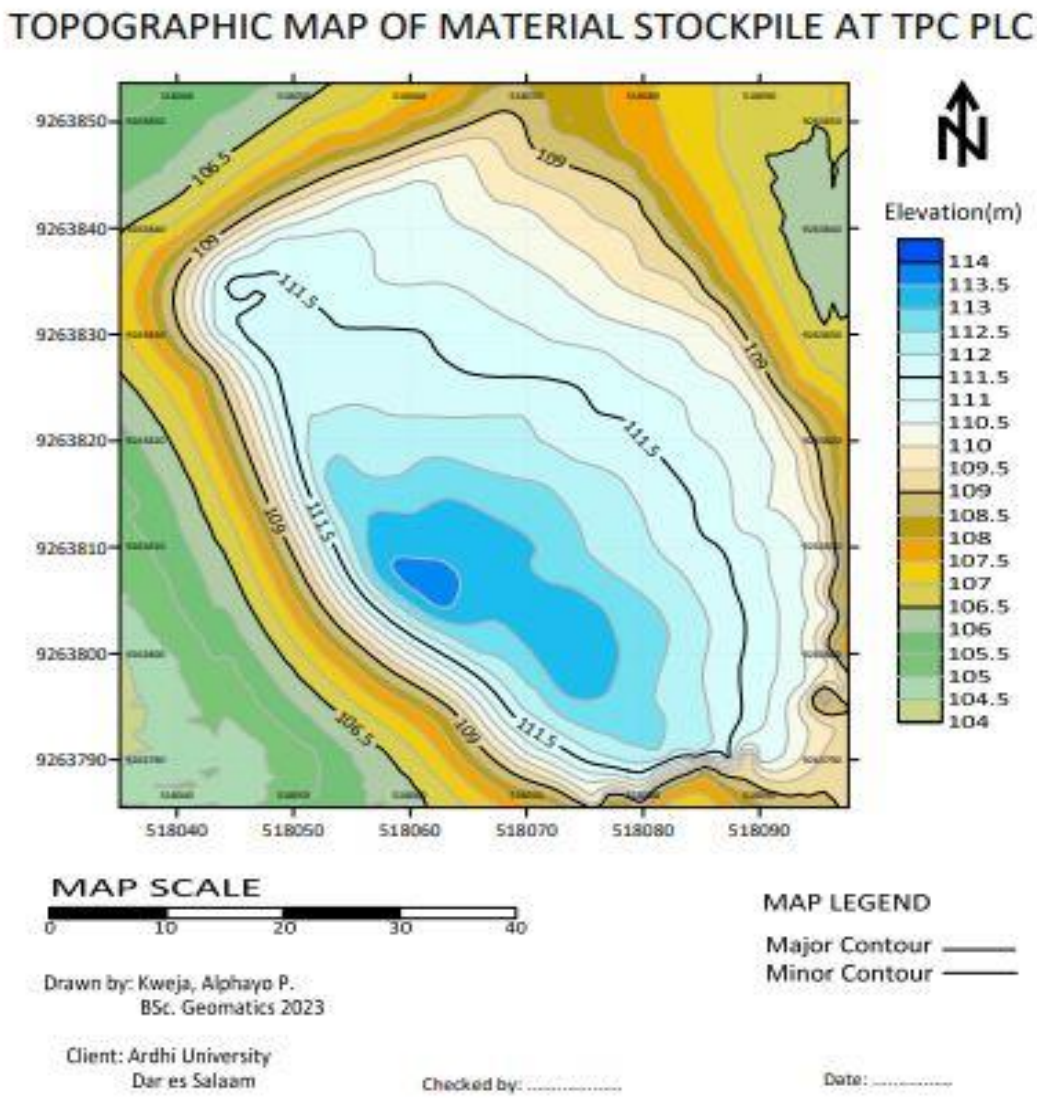

Figure 4.1 Topographic map for Stockpile 1 Photogrammetry method

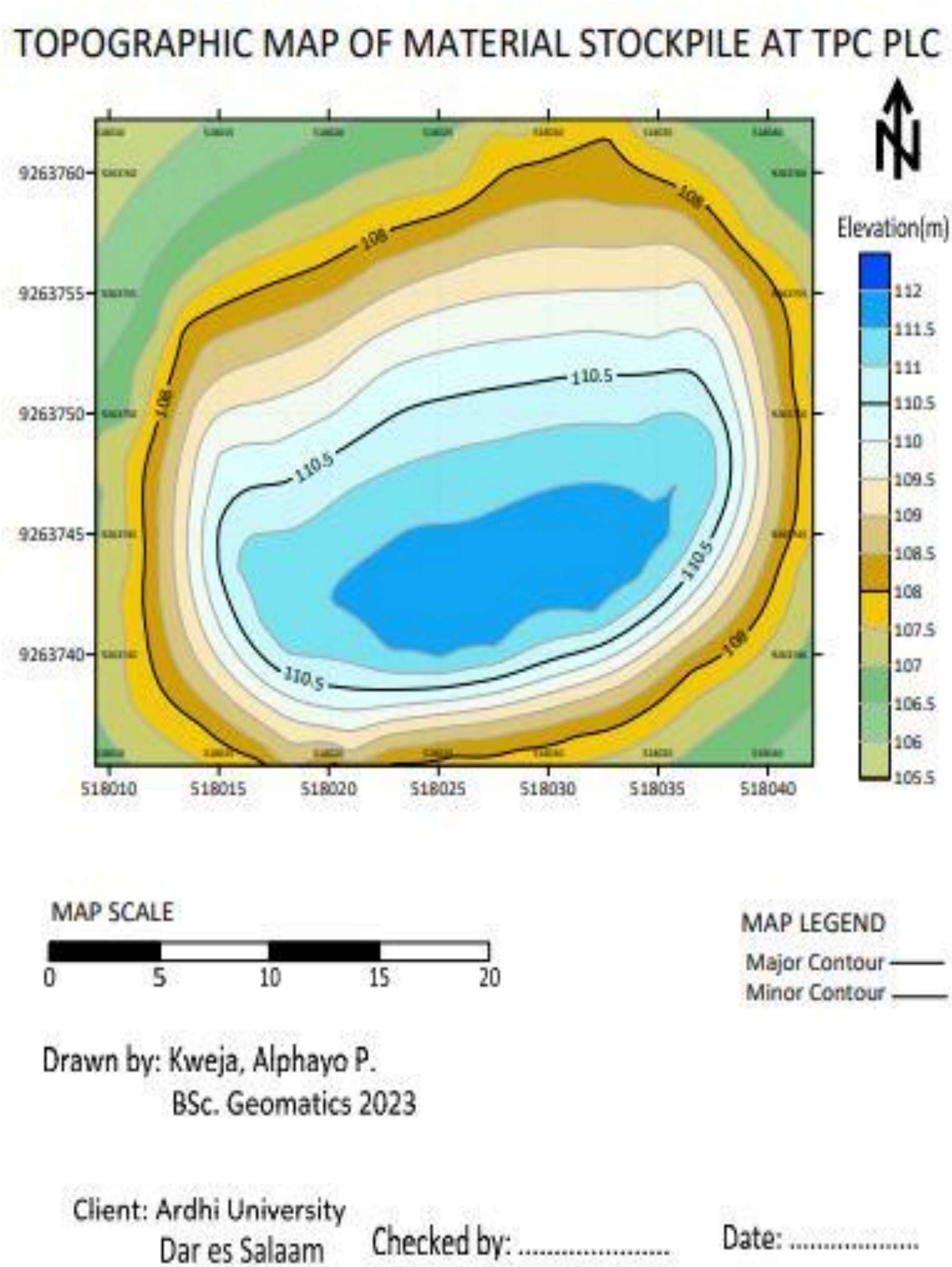

Figure 4.2 Topographic map for Stockpile 2 Conventional data

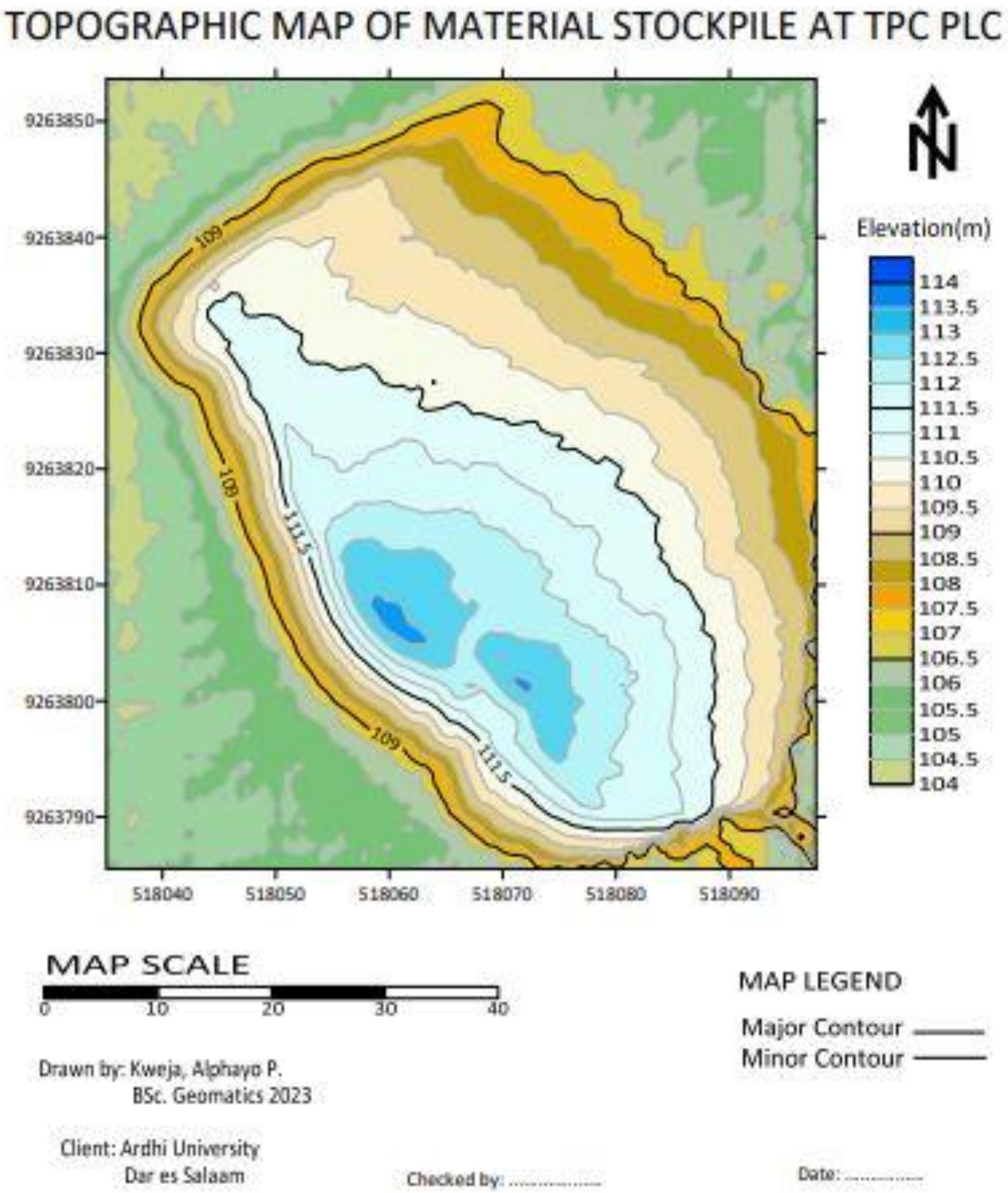

Figure 4.3 Topographic map for Stockpile 1 Conventional method

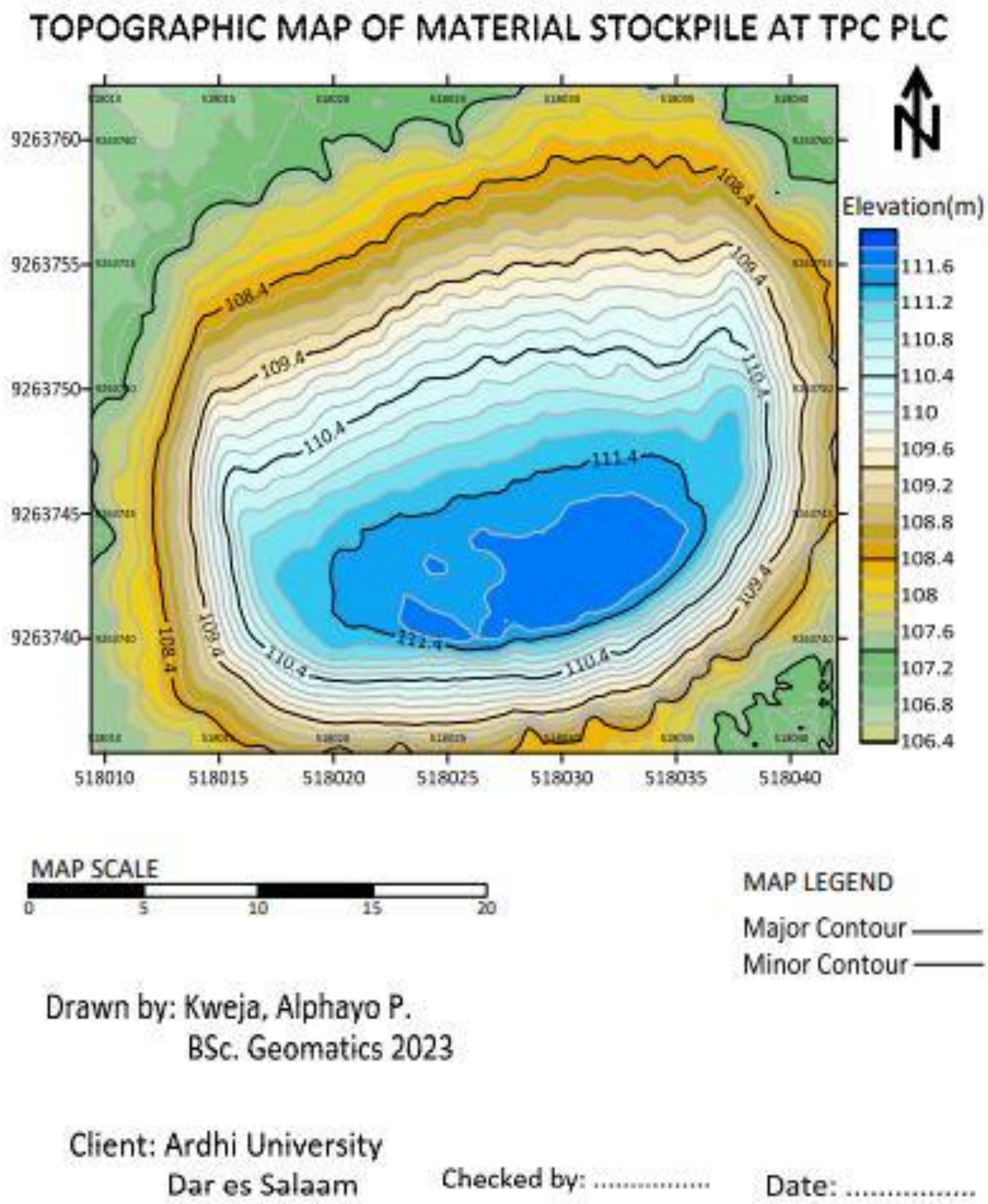

Figure 4.4 Topographic map for Stockpile 2 Photogrammetry method

4.5 Discussion of Result

From the outputs of topographic maps of the two methods, the aerial photogrammetric method produces the best 3D model resolution compared to the conventional method for topographic mapping. The best 3D model resolution for aerial photographic survey method is due to high coverage of data (cloud data) with high resolution of 30 cm to 50 cm that gives true feature representation on the ground. The Precision and accurate of the method used is influenced by GCPs surveyed by RTK method to georeferenced the images to less than centimeter accuracy. The 3D model produced by conventional method has low resolution which is caused by low data coverage compared to photogrammetry method.

In volumetric analysis using the percent difference method which allows to assess the deviation of volume between two methods. In the stockpile 1 the volume deviation percent difference between conventional and photogrammetry is 1.97% with absolute error of ± $166.05m^3$. For stockpile 2 the percent difference is 6.72% and the absolute error of the volumes is $\pm 102.37m^3$. The large deviation in stockpile 2 is influenced by factors like erosion since there was a period of heavy rainfall, wind and the data between the two method was taken in the interval of two months. The lower the percent difference indicates a higher level of agreement between the methods results.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research assessed the precision and accuracy of two methods in data collection and in producing the volume report and topographic map outputs. The two methods are conventional method of survey and photogrammetry method of survey in volume computation and topographic map production. In the case of topographic mapping the results of a 3D model, the data from the photogrammetry method gives the best 3D model or terrain compared to the conventional method data. This is shown using the stockpile tin surfaces of materials in stockpile one and two.

For the case of volume analysis between the data collected through the method of conventional and photogrammetry in the two stockpiles, the results are 1.97% and 6.72% percent difference for stockpile 1 and stockpile 2 respectively. This shows there is small deviation in volume computation which is influenced by the amount of data collected between conventional and photogrammetry methods.

For this reason, Photogrammetry data provides the best 3D model for Topographic map and also provides a superior Volume results compared to Conventional method. From a small percent difference conventional method of survey and photogrammetry method of survey can still be used for data collection for volumetric analysis by considering all principles of surveying.

5.2 Recommendation

In this research photogrammetry method have been assessed with its high-resolution data compared to the conventional method whose data have low resolution. The difference in resolution between the two method aim to show aerial photogrammetry method has the capability to provide redundant observation/data which is highly needed in surveying measurements. Its recommended that future research should survey material stockpiles for aerial photogrammetry method or other terrestrial method with conventional method using data of the same resolution. In order to assess the differences in volume computation and topographic mapping.

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APPENDECIES

Volume Reports

Topographic Maps

Control Points List