

# Comparative Analysis of Weekly Overburden Volume Using Total Station Survey and Truck Count Methods in Open-Pit Mine

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## ABSTRACT

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Topographic surveying in mining operations is used to determine the actual progress volume of excavated material. In open-pit mining, overburden volume can be estimated from Total Station survey data through surface-to-surface volume calculation and compared with production volume obtained from Truck Count data. This study evaluates weekly overburden volume estimates derived from Total Station survey data and compares them with Truck Count volume data. The results showed that the volume difference in Week 1 was -43.11 BCM with a deviation of -1.1%. In Week 2, the difference was +126.06 BCM with a deviation of +1.6%. In Week 3, the difference was -59.87 BCM with a deviation of -1.6%, while in Week 4, the difference was -112.97 BCM with a deviation of -1.1%. The total volume difference was -89.89 BCM, with an overall deviation of -0.4%. The paired t-test indicated no statistically significant difference between Total Station survey-based volume estimates and Truck Count data. Therefore, both approaches can be considered comparable for estimating weekly overburden volume in open-pit mining operations.

*Keywords:* Overburden, Survey, Truck Count, Volume, Deviation.

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## 1. INTRODUCTION

Overburden volume estimation is an important component of open-pit mining because it supports production monitoring and material movement control. Overburden is defined as soil or rock material that must be removed before ore extraction can be carried out [1]. In open-pit mining, inaccurate volume estimation may create differences between survey-based progress data and operational production records [2]. Therefore, volume comparison is needed to evaluate whether the reported production volume is consistent with the actual excavation progress.

Total Station survey data can be used to estimate overburden volume by comparing topographic surfaces from different observation periods [3]. This method is often applied using mining or civil engineering software because it can calculate excavation and filling volume from surface changes [4]. However, the accuracy of survey-based volume is influenced by surface modelling, boundary determination, point density, and field measurement quality [5]. In addition, variations in data acquisition techniques and processing methods can also affect the reliability of the resulting volume estimates [6]. These limitations may cause differences between Total Station survey-based volume estimates and production-based data.

Truck Count data can be used as an operational comparison because it is based on hauling trips and estimated hauling capacity. However, Truck Count accuracy may be affected by truck productivity, standby time, wet material condition, loading consistency, actual bucket fill factor, and differences between theoretical and actual loading volume [7]. In addition, variations in loading techniques and measurement approaches can also influence the reliability of Truck Count data [8]. Thus, comparing Total Station survey-based volume estimates and Truck Count data is important to evaluate short-term production consistency, as it allows for the identification of discrepancies between measured and estimated volumes, helps assess the reliability of operational data, and provides a more comprehensive understanding of production performance over a given period.

Previous studies have discussed survey-based volume calculation and Truck Count evaluation, but weekly comparison between both methods for overburden estimation is still limited. Susilo et al. [9] compared weekly mining excavation volumes derived from UAV-photogrammetry with Truck Count data and reported no statistically significant difference between the two estimates. However, the study used UAV-photogrammetry rather than Total Station survey data, which may lead to differences in accuracy and data acquisition procedures.

This study evaluates the agreement between weekly overburden volume estimates derived from Total Station survey data and Truck Count records in an open-pit mining operation. The comparison is conducted using volume difference, percentage deviation, and a paired t-test because both datasets represent related measurements from the same weekly periods. Weekly analysis is applied to provide a more detailed evaluation of short-term production consistency. This approach also helps identify potential discrepancies between survey-based calculations and operational records at an earlier stage.

## 2. LITERATURE REVIEW

### 2.1 *Overburden Volume Estimation in Open-Pit Mining*

Topographic survey is an important stage in overburden volume estimation because it provides field elevation data for surface modelling. Total Station is commonly used in terrestrial surveying to measure horizontal distance, vertical angle, and elevation points for topographic mapping. Studies comparing GPS, GNSS, and aerial survey data for volume calculation show that the quality and distribution of topographic data affect the representation of the observed surface and the resulting volume estimate [10]. Other studies also indicate that variations in data acquisition methods can influence the accuracy of volume estimation results [11]. In addition, differences in survey resolution and point density can lead to discrepancies in surface modelling outcomes. Therefore, selecting an appropriate data acquisition technique is crucial to ensure reliable and consistent volume calculations.

### 2.2 *Surface-Based Volume Calculation from Total Station Survey Data*

Surface-based volume calculation uses two surface models from different observation periods to determine the volume of excavated or filled material [12]. In this study, the surfaces were generated from Total Station survey data and compared using the Cut and Fill approach [13]. The elevation difference between the initial and final surfaces was used to estimate weekly overburden volume [14]. Previous studies using UAV-derived DEMs and surface models have shown that elevation data quality, surface generation, and data-processing procedures influence the reliability of volume calculation [11]. These factors can introduce uncertainties if not properly controlled, particularly in areas with complex terrain or limited ground control points. Therefore, careful planning of data acquisition and processing workflows is essential to ensure accurate and consistent volume estimation results.

### 2.3 *Truck Count and Volume Comparison*

Truck Count is an operational method used to estimate production volume based on hauling trips and hauling capacity. This method is practical for production monitoring because it represents the actual hauling activity recorded in the field. Sihombing et al. [15] compared overburden volume derived from survey data and

Truck Count data and showed that differences may occur between both methods due to survey and operational factors.

Because the Total Station survey-based and Truck Count volumes in this study were obtained from the same weekly observation periods, the datasets can be treated as paired observations. A paired t-test can therefore be used to examine whether the mean difference between the two volume estimates is statistically significant [16].

### 3. METHODS

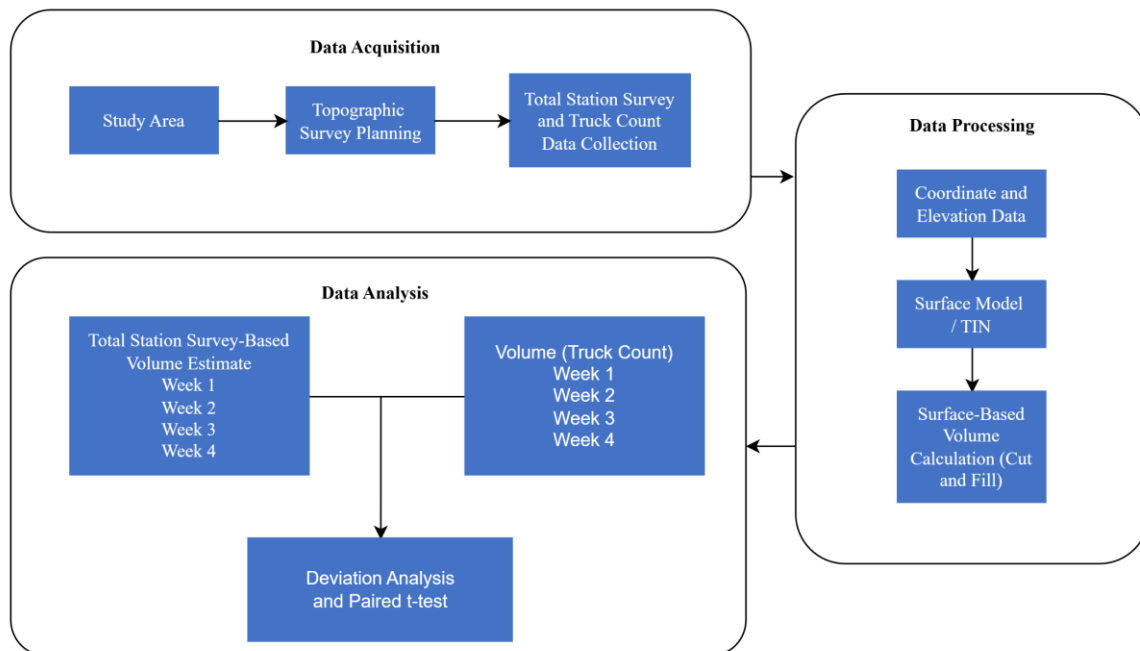


Figure 1. Research Stages

Figure 1. illustrates the sequence of research activities conducted in this study. The workflow begins with data acquisition, which includes determining the study area, preparing the topographic survey, and collecting data from Total Station measurements and Truck Count records. The survey results are then processed into coordinate and elevation data to develop a surface model or TIN. This model is used to derive overburden volume from Total Station survey data through a surface-to-surface Cut and Fill calculation. In the final stage, the weekly Total Station survey-based volume estimate is compared with the weekly Truck Count volume. The comparison is assessed through volume difference, deviation percentage, and paired t-test to evaluate the agreement between the two volume estimation methods.

Before deriving overburden volume from Total Station survey data, the weekly topographic data were reviewed to identify surface changes during the observation period. The topographic models from Week 1 to Week 4 provide a visual representation of excavation progress and serve as the basis for surface comparison. The combined weekly topographic conditions are presented in Figure 2.

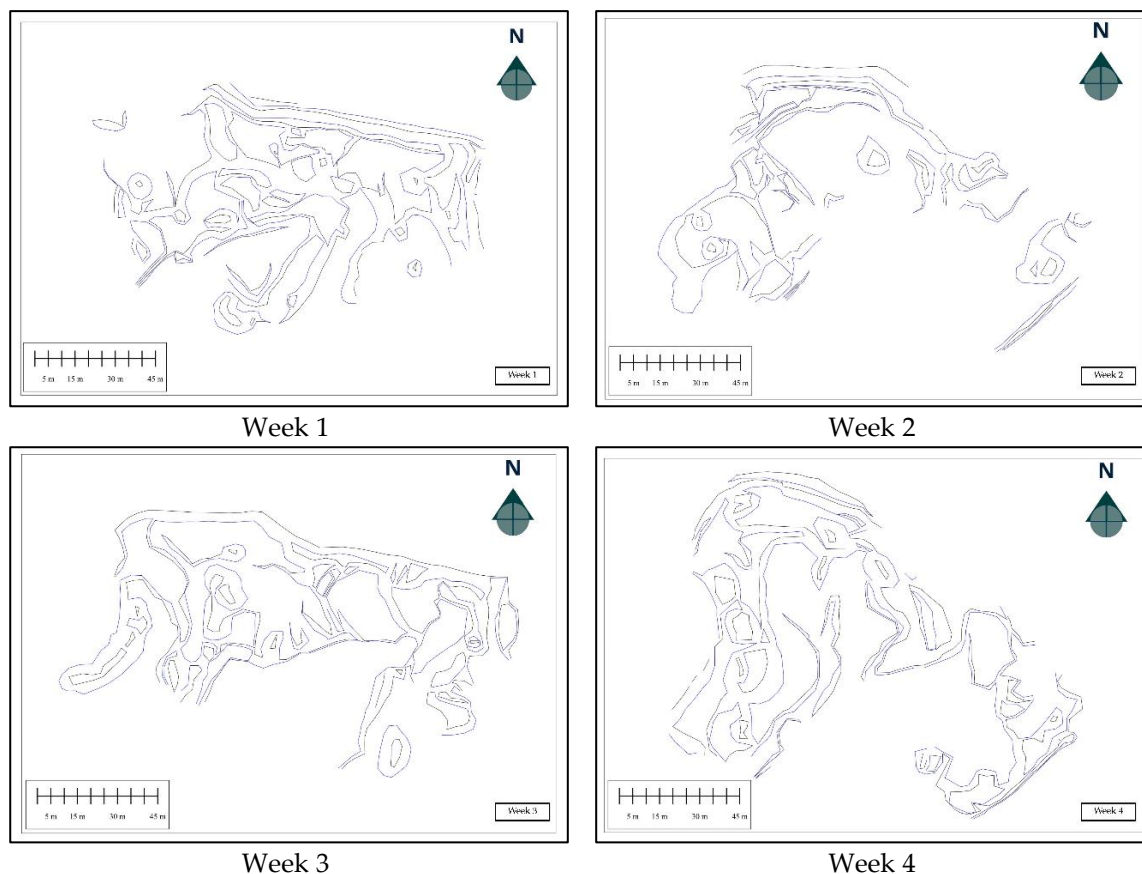


Figure 2. Weekly Topographic

Figure 2 presents the weekly topographic condition of the study area from Week 1 to Week 4. The topographic data were obtained from Total Station measurements and used as the basis for surface modelling and surface-to-surface Cut and Fill volume calculation. Changes in surface elevation between weekly periods indicate the progress of overburden excavation and provide the main input for comparing survey-based volume with Truck Count data.

#### 4. RESULTS AND DISCUSSION

##### 4.1 Comparative Analysis of Overburden Volume in Week 1

The overburden volume in Week 1 was derived from Total Station survey data using a surface-to-surface Cut and Fill calculation within the defined calculation boundary. The result was then compared with the Truck Count volume obtained from recorded hauling trips and the effective hauling capacity used during the observation period. The comparison is presented in Table 1.

Table 1. Overburden Volume Comparison in Week 1

Week	Total Station Survey-Based Volume (BCM)	Truck Count (BCM)	Difference (BCM)	Deviation (%)
1	4,030.89	4,074.00	-43.11	-1.1%

Based on Table 1, the Total Station survey-based volume estimate was 4,030.89 BCM, while the Truck Count volume was 4,074.00 BCM. The Truck Count result was higher by 43.11 BCM, resulting in a deviation of -1.1%. This difference indicates that the survey-based and operational-based volume estimates were relatively close during Week 1.

#### 4.2 Comparative Analysis of Overburden Volume in Week 2

The overburden volume in Week 2 was determined by comparing the survey progress surface of Week 1 with the survey progress surface of Week 2. The Total Station survey-based volume was then compared with the Truck Count volume recorded during the same weekly period. The comparison is presented in Table 2.

Table 2. Overburden Volume Comparison in Week 2

Week	Total Station Survey-Based Volume (BCM)	Truck Count (BCM)	Difference (BCM)	Deviation (%)
2	7,733.46	7,607.40	+126.06	+1.6%

Based on Table 2, the Total Station survey-based volume estimate was 7,733.46 BCM, while the Truck Count volume was 7,607.40 BCM. The Total Station survey-based volume estimate was higher by 126.06 BCM, producing a deviation of +1.6%. This was the largest absolute difference among the four weekly observations.

#### 4.3 Comparative Analysis of Overburden Volume in Week 3

The overburden volume in Week 3 was calculated by comparing the survey progress surfaces from Week 2 and Week 3. The resulting Total Station survey-based volume estimate was compared with Truck Count data. The comparison is presented in Table 3.

Table 3. Overburden Volume Comparison in Week 3

Week	Total Station Survey-Based Volume (BCM)	Truck Count (BCM)	Difference (BCM)	Deviation (%)
3	3,687.06	3,746.93	-59.87	-1.6%

Based on Table 3, the Total Station survey-based volume estimate was 3,687.06 BCM, whereas the Truck Count volume was 3,746.93 BCM. The Truck Count volume was higher by 59.87 BCM, resulting in a deviation of -1.6%. Although the volume difference was relatively small, the percentage deviation was influenced by the lower total volume recorded during Week 3.

#### 4.4 Comparative Analysis of Overburden Volume in Week 4

The overburden volume in Week 4 was calculated from the comparison between the survey progress surfaces of Week 3 and Week 4. The resulting Total Station survey-based volume estimate was compared with Truck Count data obtained during the same period. The comparison is presented in Table 4.

Table 4. Overburden Volume Comparison in Week 4

Week	Total Station Survey-Based Volume (BCM)	Truck Count (BCM)	Difference (BCM)	Deviation (%)
4	9,965.90	10,078.87	-112.97	-1.1%

Based on Table 4, the Total Station survey-based volume estimate was 9,965.90 BCM, while the Truck Count volume was 10,078.87 BCM. The Truck Count result was higher by 112.97 BCM, producing a deviation of -1.1%. Week 4 recorded the highest weekly overburden volume for both methods, while the deviation remained within the established tolerance limit.

#### 4.5 Overall Volume Comparison and Statistical Evaluation

The overall weekly comparison between Total Station survey-based and Truck Count volume estimates is presented in Table 5. The deviation was calculated using the Total Station survey-based volume estimate as the reference value.

Table 5. Weekly Overburden Volume Comparison

Week	Total Station Survey-Based Volume (BCM)	Truck Count (BCM)	Difference (BCM)	Deviation (%)
1	4,030.89	4,074.00	-43.11	-1.1%
2	7,733.46	7,607.40	+126.06	+1.6%
3	3,687.06	3,746.93	-59.86	-1.6%
4	9,965.90	10,078.88	-112.97	-1.1%
Total	25,417.31	25,507.20	-89.89	-0.4%

Based on Table 5, the deviation values ranged from -1.6% to +1.6%. The highest positive deviation occurred in Week 2, while the highest negative deviation occurred in Week 3. The total Total Station survey-based volume was 25,417.31 BCM, whereas the Truck Count volume was 25,507.20 BCM. The total difference was -89.89 BCM, with an overall deviation of -0.4%.

The results indicate that a higher weekly volume does not necessarily produce a higher percentage deviation. For example, Week 4 had the highest volume for both methods but produced a deviation of only -1.1%. This condition indicates that deviation is affected not only by total material volume but also by the consistency of survey data, surface formation, loading conditions, and hauling records.

A paired t-test was conducted to determine whether there was a statistically significant difference between Total Station survey-based and Truck Count volume estimates. The hypotheses were formulated as follows:

$H_0$  : There is no significant difference between overburden volume estimates derived from Total Station survey data and Truck Count records.

$H_1$  : There is a significant difference between overburden volume estimates derived from Total Station survey data and Truck Count records.

The paired t-test results are presented in Table 6.

Table 6. Paired t-Test Result for Weekly Overburden Volume Estimates

Variable	t Statistic	Critical t Value ( $\alpha = 0.05$ ; $df = 3$ )	p-value	Decision
Overburden volume	-0.4347	$\pm 3.1824$	0.6932	Fail to reject $H_0$

Based on Table 6, the absolute t statistic value of 0.4347 was lower than the two-tailed critical t value of 3.1824. In addition, the p-value of 0.6932 was greater than the significance level of 0.05. Therefore, the null hypothesis was not rejected, indicating that there was no statistically significant difference between the Total Station survey-based and Truck Count overburden volume estimates.

## CONCLUSION

This study showed that weekly overburden volume estimates derived from Total Station survey data and Truck Count records were comparable in open-pit mining operations. The total Total Station survey-based volume was 25,417.31 BCM, while the Truck Count volume was 25,507.20 BCM, resulting in a total difference of -89.89 BCM and an overall deviation of -0.4%. Weekly deviations ranged from -1.62% to +1.63%. The paired t-test result showed a t statistic of -0.4347, lower than the critical t value of  $\pm 3.1824$ , with a p-value of 0.6932 greater than 0.05. Therefore, there was no statistically significant difference between the two methods.

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