COMPARISON OF BIM AND CONVENTIONAL METHOD TO ANALYZE DIMENSION AND VOLUME OF ABUTMENT

Rayhan Anugrah Yuliano[1], Nunung Martina[2]*, Safri[3]

[1,2,3] Civil Engineering Department, Politeknik Negeri Jakarta, Depok, 16424, Indonesia

e-mail: rayhan.anugrahyuliano.ts17@mhsw.pnj.ac.id [1]; nunung.martina@sipil.pnj.ac.id[2]*
safri@sipil.pnj.ac.id[3]

ABSTRACT

The development of the industrial era 4.0 is rapid, one of which is the BIM (Building Information Modeling) method for surveying activities, namely 3D Scanning. The 3D Scanning method, which can obtain millions of points in point clouds in one scan, is expected to provide higher accuracy and more efficient and effective operating time than conventional methods. Conventional methods, which still apply human plotting, require more time and human resources because they have to move from one point to another, and their accuracy is highly dependent on the quality of human resources. This research was conducted at the Interchange Project of the Batang Industrial Estate, Central Java, and aimed to compare the dimensions, volume, and shop drawings of the 3D Scanning method with the conventional method and the advantages of the 3D Scanning and Modeling method. The results obtained in this study are that there is an average dimension difference of 0.007 m from the shop drawing image, then there is a difference in the average coordinate point of 0.028 m which causes the Abutment position to shift from the shop drawing image. BIM is one method for get the volume of structures on Interchange Project with careful results and faster process. The calculated volume is based on shop drawings. The results showed that the difference between the conventional BIM method in the volume of concrete was 1.156%, and in the granular heap, there was a difference of 1.292%. The advantages of these 2 BIM methods are how they operate, which has started to implement an automation system and requires less time than conventional methods.

Keywords : *3D Scanning; Building Information Modeling (BIM); Conventional Method; Point Cloud; Surveying*

INTRODUCTION

A Surveying or mapping survey is a survey conducted to ascertain the relative position of the earth's surface, both above and below the earth's surface. In a universal sense, surveys can be interpreted as a science that deals with all procedures for measuring and collecting data about the earth's shape and the environment, processing information, and informing various products produced for various needs (Blachut, Chrzanowski, Saastamoinen, 2012). Due to the need for faster and more accurate surveying data, the 3D Scanning method was created. The 3D Scanning method is an excellent method, which can determine soil displacement accurately, and also based on the research that has been done, this method also produces good output for the resolution and quality of measurements (Remondino, 2011; Soudarissanane et al., 2011). Using 3D Scanning method, the results shows there is an increase of for the volume of concrete material, volume of reinforcement weight, and the cost, this is caused by a more accurate design for the model (Utomo, 2022).

Before the 3D Scanning method, survey tools such as Water pass, Theodolite and Total Station were used for surveying purposes. The main problem with using this tool is that surveying technology still

applies human plotting, meaning that the surveyor must go to the desired point to obtain coordinate data so that it takes more time (Isa & Lazoglu, 2017; Pu et al., 2011). Calculation of dimensions and volumes can be done using 3D Scanning quickly. Compared to other measuring instruments, BIM has a higher level of accuracy and operating time that is much more effective and efficient than conventional methods (Hardin, & McCool, 2015; Shanbari et al., 2016). Conventional volumes on construction work can be obtained from reading and calculating the Final Engineering Plan (RTA) Drawings (Kim et al., 2015).

In the BIM dimension model, 3D Scanning is included in the BIM 3 Dimension model type. The results obtained from this 3D Laser Scanning measurement are point clouds or point clouds with three-dimensional coordinates to where the TLS tool stands. By using the BIM or GIS tool is enabled us to get three variables data (Arbad et al., 2019). The tool used is a Terrestrial Laser Scanner or what is often referred to as TLS is a survey and mapping technology that operates by reflecting the tool after the laser is fired at an object (Holst & Kuhlmann, 2016).

The Point cloud is a collection of data points that contain coordinate information. In a three-dimensional coordinate system, these points are usually defined by coordinates X (easting), Y (northing), and Z (elevation), and these points can describe the shape of the outer surface of the object (Shi et al., 2019; Zeybek & Şanlıoğlu, 2019).

Georeference process is carried out so that TLS data is registered in the integrated geospatial data. Georeference is done by registering all point cloud data from objects into an external coordinate system. There are two types of georeferenced methods, namely direct and indirect (Uysal et al., 2015). The high powerfulness of TLS technique for quick 3D data acquisition is extending its use to many fields. To further reduce the surveying time and to simplify all operational tasks, the TLS direct georeferencing may be a very suitable approach instead of the technique based on ground control points (targets). This chance is allowed by the most part of existing instruments, as a default or as an optional capability (Scaioni, 2005).

The problem in this research is how the differences in volume, dimensions, and shop drawings on the work of the Batang Industrial Estate Interchange (KIB Interchange) Project Overpass structure between the results of conventional measurement data and using BIM and what are the advantages of the BIM method compared to the conventional method in terms of modeling results and the volume of KIB Interchange Project (Duy-Cuong Nguyen, 2021).

The purpose of this study is to analyze the differences in volume, dimensions, and shop drawings on the work of the Overpass structure of the Batang Industrial Estate Interchange between the results of conventional measurement data and using BIM and to analyze the advantages of the BIM method compared to the conventional method in terms of modeling results and volume. The benefit of the research is to optimize the use of the BIM method in industrial era 4.0, especially for the academic environment (Isailović, 2020).

The Batang Industrial Estate Interchange construction environment is complex, the construction is difficult, the requirements are high, the construction period is tight, the coordination relationship is many, and the amount of information is huge. The application of BIM technology in bridges can solve

these problems well. The application of BIM technology in the bridge construction stage is still in its infancy However, BIM technology has unparalleled advantages over traditional management models in finding drawing errors, technical disclosure, engineering quantity statistics, collision detection, and information integration.The BIM cloud platform can realize the information management of the whole process of bridge engineering from design to construction to operation and maintenance, so as to achieve refined project management and ensure the realization of the goals of project quality, safety, schedule, cost, and environmental protection (Tian, 2021).

METHODS

In this research, the method used was the quantitative method. Quantitative research methods were based on the philosophy of positivism used to examine certain populations or samples. (Gunawan, 2013).

Furthermore, to get the advantages and disadvantages of the 3D Scanning method, it was reviewed from the results of scanning and modeling as well as interviews with respondents who meet the qualifications.

The research was located in the Batang Industrial Estate Interchange Development Project, Central Java. The time for data collection for surveying the Abutment Overpass structure was April 8-9, 2021. Meanwhile, modeling was carried out during April – June 2021.

The process in this research can be seen in Figure 1.

1. Data Collecting
   At this stage, conventional surveying data, RTA documents and shop drawings from the project will be collected. The data collected will be used for reference point Benchmark (BM) for primary data collection using TLS and the next stage of comparative analysis.

2. Primary data were taken using TLS After obtaining the BM data for the establishment of the TLS tool, a scanning process will be carried out on the Batang Industrial Estate Interchange Overpass at the planned point. Then the raw point cloud data processing will be TLS data, namely the georeference process using the help of Trimble Business Center and Autodesk Recap Pro software which is carried out to register local coordinate data into global coordinate data.

3. Making overpass modelling
   To complete the structure of the Overpass, modeling of the overpass was carried out using the help of Autodesk Civil 3D and Autodesk Revit software. The database of the modeling process is the RTA document and shop drawings.

4. Result analysis of 3D Scanning and Modelling
   After the entire 3D Scanning and Modeling process is completed, the output volume, dimensions, and coordinates will be obtained.

5. Comparative Analysis of the results of dimensions, coordinates, and volumes between the BIM Method and the Conventional Method
   The results obtained in the scanning and modeling process will then be compared with conventional data, both from RTA and shop drawings. At this stage, the difference in dimensions, coordinates, and volume between the BIM method and the conventional method will be obtained

6. Analysis of interviews with selected respondents
   Apart from reviewing the results of scanning and modeling, interviews

with respondents who have met the qualifications are needed, in this case, are Surveyor Experts who have experience in their fields to find out what are the advantages and disadvantages of the BIM method.

the scan-to-BIM workflows offer a considerable list of challenges to be faced for its properly application. Issues like operator expertise in all stages of the process, environmental conditions for scanning, high costs associated to the instruments and software for processing and modeling data (it will depend on the application and level of accuracy required for the project), and the interoperability between different platforms and file formats make the accessibility to this methodology more difficult. However, thanks to the correct choice of the tools that use point cloud data and BIM technology, the proposed scan-to-BIM workflow was successfully applied to the case study, being able to represent the real conditions of the existing structure, in its totally, and identify different quality issues committed during the process. (Pinho, 2021).

RESULTS AND DISCUSSION

In this research, the comparison of dimensions and coordinates between the BIM method (3D Scanning) and the conventional method will only be carried out on the Abutment structure. Due to the limited number of Terrestrial Laser Scanner units and limited mobilization during the Covid-19 pandemic, the arrival of the equipment must adjust to the project's progress.

3D Scanning

The 3D Scanning process is carried out using the Trimble SX 10 Terrestrial Laser Scanner at five predetermined points. The object in question is the Abutment structure at the Overpass Interchange of the Batang Industrial Estate. After the raw point cloud data from TLS data has been obtained, then the georeferencing process is carried out to obtain the global coordinates and the required dimensions. The results of 3D Scanning can be seen in Figure 2.

Later, to get the volume of concrete in the Overpass structure as a whole, export the results of 3D Scanning to Autodesk Revit. However, because only the Abutment structure is obtained from the 3D Scanning method, the process is carried out using another BIM method, namely Modeling.

Modelling

The overpass structure modelling is continued by adding other overpass sub-structures, namely bored pile, lean concrete pile cap, pile cap, wingwall, thin concrete step plate, step plate, slab, edge diaphragm, middle diaphragm, parapet and median barrier. Then the granular volume is added to each abutment. The supporting software used is Autodesk Revit and Autodesk Civil3D. The results of modelling can be seen in Figure 3

Dimension Analysis

The comparison between the BIM method and the conventional method will be carried out on the dimensions of the abutment structure, namely the length, width and height. Here are the results of the analysis

From the table 1, it can be seen that there is a difference in the dimensions of the average length of 0.003 m, the width of 0.003 m, the height of 0.005 m, and if all of them are averaged it becomes 0.004 m between the 3D Scanning method and the conventional method. In codes L3, L6, T4, and T8, the difference is closest to the shop drawing, which is 0.002 m.

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Similar to ABT 1, ABT 2 will be calculated the difference in dimensions between the 3D Scanning method and the conventional method. The results obtained are as Table 2

From the table 2, it can be seen that there is a difference in the dimensions of the average length of 0.003 m, the width of 0.003 m, the height of 0.005 m, and if all of them are averaged it becomes 0.004 m between the 3D Scanning method and the conventional method. In codes L3, L6, T4, and T8, the difference is closest to the shop drawing, which is 0.002 m.

Coordinate Analysis

To find out whether the abutment position is by with the shop drawings, an analysis of the existing coordinates of the TLS with conventional data will be carried out. The results obtained are as follows:

Figure 4 to Figure 9 illustrates the analysis of the comparison of existing coordinates from TLS with conventional data. Grid X shows the sequence of coordinate points studied and the grid y shows the difference in the coordinate point between the method of using TLS and conventional which is in the drawing shop

In figure 4, it can be seen that the coordinate points compared to the conventional method data are estimated to have an average difference of 0.036 m and at point 2 ABT 1 easting has the closest difference to the shop drawing. And the difference is 0.005 m.

As for the comparison of the northing coordinates of ABT 1, it will be explained in the graph as follows:

In figure 5, it can be seen that the coordinate points compared to the conventional method data are estimated to have an average difference of 0.057 m and at point 7 northing ABT 1 has the

closest difference to the shop drawing. And the difference is 0.005 m

And for the comparison of height or elevation of ABT 1 between the BIM method and the conventional method, it will be explained as follows:

In Figure 6, it can be seen that the elevation compared to conventional method data is estimated to have an average difference of 0.006 m and at points 7 and 13 elevation ABT 1 has the closest difference to the shop drawing. And the difference is 0.001 m.

Similar to Abutment 1, Abutment 2 will also conduct a comparative analysis of the coordinates of the Batang Industrial Estate Interchange project by comparing the results of 3D Scanning data processing with a conventional shop drawing data owned by the Batang Industrial Estate Interchange Project Team. In this study, the results of the comparison of the easting coordinates obtained are as follows:

In Figure 7, it can be seen that the coordinate points compared to the conventional method data are estimated to have an average difference of 0.015 m and at point 2 ABT 2 easting has the closest difference to the shop drawing. And the difference is 0.012 m.

As for the comparison of the northing coordinates of ABT 2, it will be explained in the table and curve as follows:

In Figure 8, it can be seen that the coordinate points compared to the conventional method data are estimated to have an average difference of 0.037 m and at point 11 ABT 2 northing has the closest difference to the shop drawing. And the difference is 0.004 m.

And for the comparison of height or elevation of ABT 2 between the BIM method and the conventional method, it will be explained as follows:

In Figure 9, it can be seen that the elevation compared to conventional method data is estimated to have an average difference of 0.017 m and at points 6 and 11 elevation ABT 1 has the closest difference to the shop drawing. And the difference is 0.001 m.

In the journal Study of Utilization of Terrestrial Laser Scanner Technology to Calculate Overburden Stripping Volume at Pit 2 Electrification of Banko Barat Pt. Bukit Asam, Tbk. Tanjung Enim, South Sumatra, written by Ezil Defri Maharfi, the measurement of large areas and various surfaces that still use the Total Station is considered less effective because of the length of time it takes and the low level of accuracy. Therefore, one application of the BIM method, namely 3D Scanning using TLS, can measure volume quickly and produce detailed and high-density volume size data.

Volume Analysis

The result of the modeling process that has been carried out is the volume of concrete and granular. Here are the results:

In ABT 1, the ratio of the volume of concrete between the BIM method and the BIM method has an average deviation of 1.52%. It can be seen in Figure 10.

While in ABT 2, the ratio of the volume of concrete using the BIM method compared to the conventional method is 0.61%. It can be seen in Figure 11

For the connecting structure ABT 1 and ABT 2, there is a difference of 1.34% of the concrete volume between the BIM method and the conventional method. It can be seen in Figure 12

Moreover, for granular piles, there is an average difference of 1.292% in ABT 1 and ABT 2 between the BIM method and the conventional method. It can be seen in Figure 13.

Interview Analysis

To strengthen the results of the analysis of dimensions, coordinates, and volume, interviews were conducted on respondents who meet the qualifications, namely the BIM Infrastructure Expert to find out what the advantages and disadvantages of the BIM method are as follows:

1. Calculation between BIM results (in this case 3D Scanning is more emphasized) compared to using conventional methods using TS or Theodolite will produce more detailed output. But what needs to be noted is that the user must really understand and understand how to operate the tool. Another thing that can affect the results of measuring dimensions and volumes in the field is the Benchmark point whose accuracy must be high which is determined by the determination of the distance and angle of data collection.
2. For 3D Scanning, the most effective and appropriate application at this time is for drawing existing drawings or As Built Drawings. For drawing shop drawings, it will be a little difficult because the accuracy will be slightly disturbed. After all, during the data collection process, project activities will affect the output.
3. The difficulty that is most often felt is the creation of Benchmark points (BM). Usually, BM points are only made with temporary stakes and of course, as the project progresses, its position will shift. Therefore, it is very necessary to check the position of the BM periodically.
4. In road or bridge projects, Total Station or Theodolite is still easier to use than TLS. Because TLS has a weakness, namely it is difficult to stake out when many mediums

hinder the scanning process. However, this tool is already more modern and sophisticated because it is equipped with a scanner.

CONCLUSION

Based on the results of data analysis on the dimension comparison between the BIM method and the conventional method of Abutment 1 structure, the difference between the conventional method and the BIM method for the dimensions of length is 0.021 m, width is 0.003 m, height is 0.005 m and if all of them are averaged to 0.009 m. For plotting the coordinates, it is found that the average difference for the x-coordinate is 0.036 m, the y-coordinate is 0.057 m, and the z-coordinate is 0.006 m. Whereas in the Abutment 2 structure, the difference between the conventional method and the BIM method for length dimensions is 0.003 m, width is 0.003 m, height is 0.005 m, and if all of them are averaged, it becomes 0.004 m. For plotting the coordinates, it is found that the average difference for the x-coordinate is 0.015 m, the y-coordinate is 0.037 m, and the z-coordinate is 0.017 m. For the volume of concrete work, there is an average difference of 1.156%, while in the granular heap, there is an average difference of 1.292%. From the results of the 3D Scanning and Modeling analysis, it can be concluded that the advantages offered are that the time for data retrieval and processing is faster than the conventional method. Infrastructure Experts.

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Appendix

Table 1. Dimension Difference at Abutment 1

Point	BIM Method (m)	Conventional Method (m)	Difference
P1	17.536	17.557	0.021
P2	17.536	17.557	0.021
P3	17.536	17.557	0.021
P4	17.536	17.557	0.021
P5	17.536	17.557	0.021
L1	10.729	10.733	0.004
L2	1.083	1.085	0.002
L3	0.609	0.612	0.003
L4	10.765	10.768	0.003
L5	1.086	1.088	0.002
L6	0.611	0.614	0.003
T1	1.489	1.492	0.003
T2	1.000	1.006	0.006
T3	0.500	0.505	0.005
T4	0.296	0.300	0.004
T5	1.489	1.492	0.003
T6	1.000	1.006	0.006
T7	0.500	0.505	0.005
T8	0.296	0.300	0.004

Table 2. Dimension Difference at Abutment 2

Titik	Metode BIM (m)	Metode Konvensional (m)	Selisih
P1	17.216	17.219	0.003
P2	17.216	17.219	0.003
P3	17.216	17.219	0.003
P4	17.216	17.219	0.003
P5	17.216	17.219	0.003
L1	10.498	10.501	0.003
L2	1.060	1.064	0.004
L3	0.599	0.601	0.002
L4	10.498	10.501	0.003
L5	1.060	1.064	0.004
L6	0.599	0.601	0.002
T1	1.487	1.491	0.004
T2	1.008	1.015	0.007
T3	0.500	0.505	0.005
T4	0.298	0.300	0.002
T5	1.487	1.491	0.004
T6	1.008	1.015	0.007
T7	0.500	0.505	0.005
T8	0.298	0.300	0.002
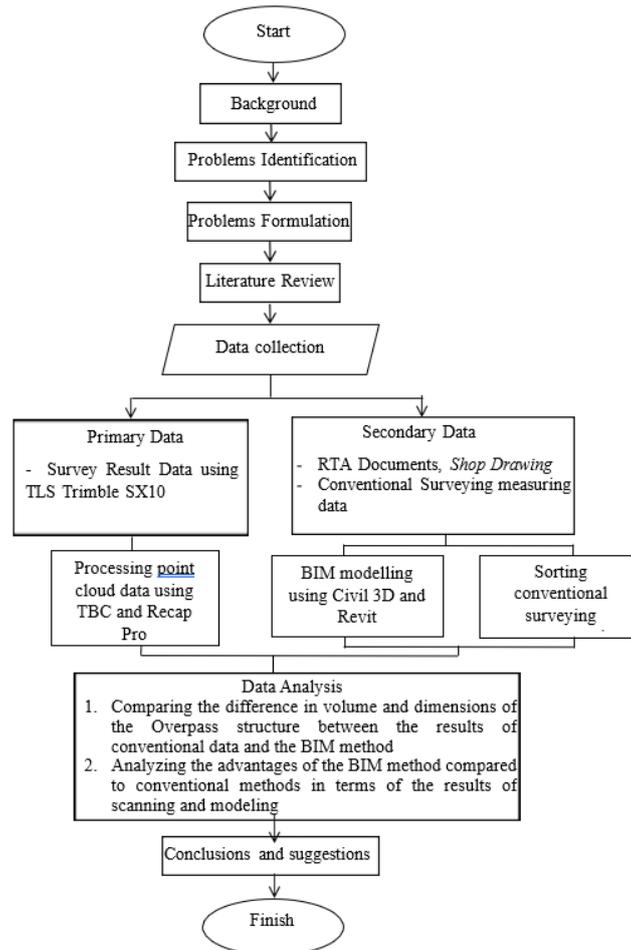
Figure 1. Research Flowchart

Figure 2. 3D Scanning results on Abutment
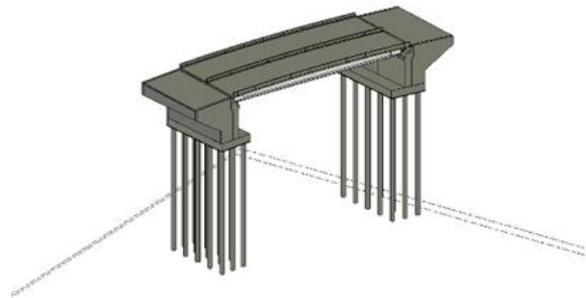
Figure 3. Modelling results on Overpass
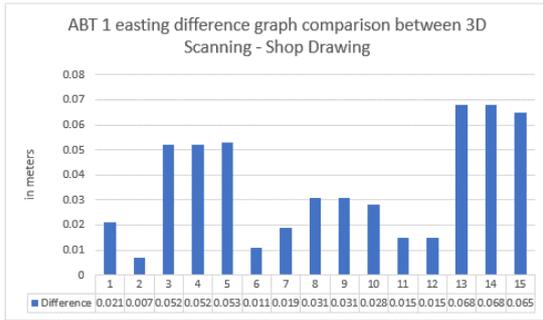
Figure 4. Coordinate difference easting at Abutment 1
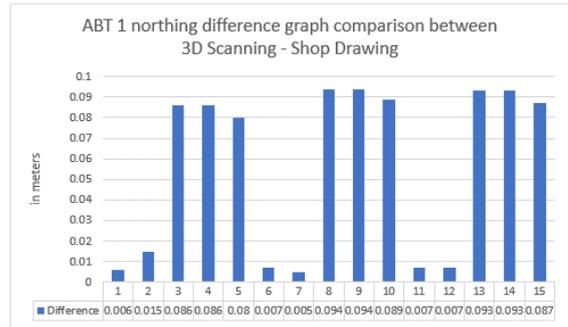
Figure 5. Coordinate difference northing at Abutment 1
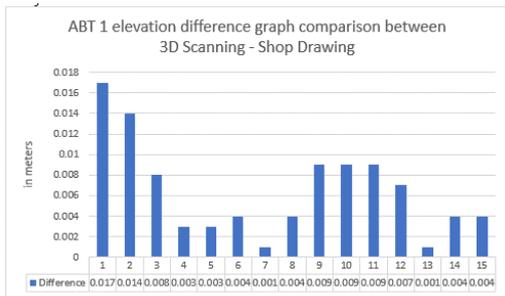
Figure 6. Coordinate difference elevation at Abutment 1
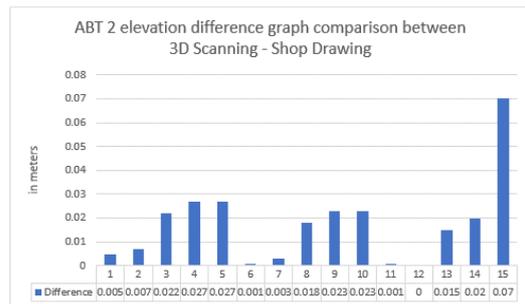
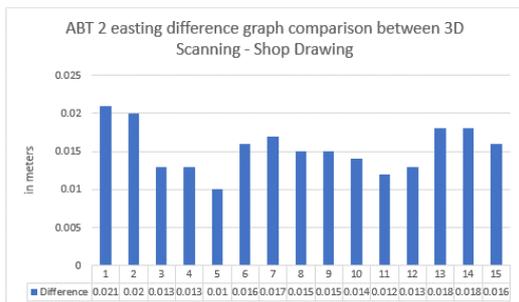Figure 9. Coordinate difference elevation at Abutment 2

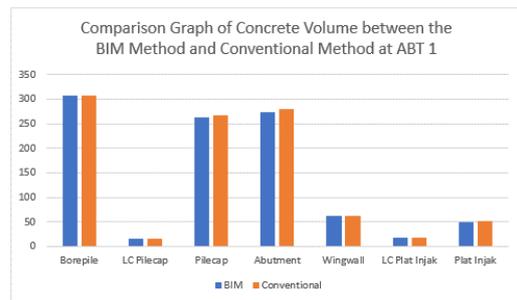Figure 7. coordinate difference easting Abutment at 2
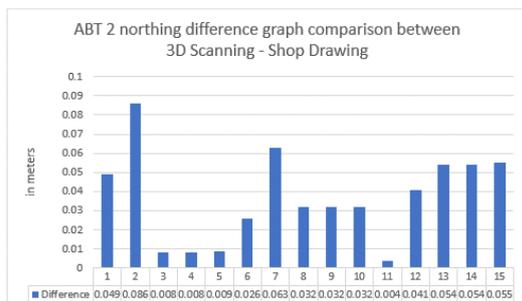

Figure 10. Concrete Volume deviation at ABT 1

Figure 11. Concrete Volume deviation at ABT 2

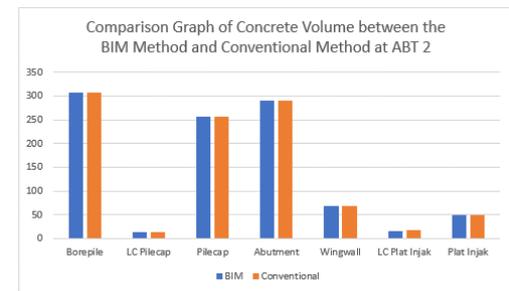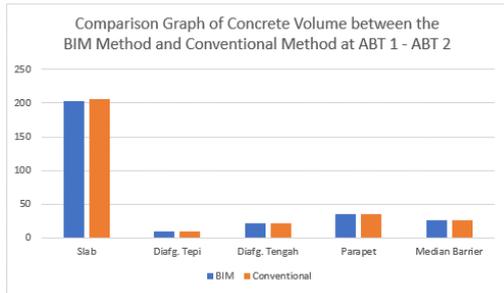Figure 8. Coordinate difference northing Abutment at 2
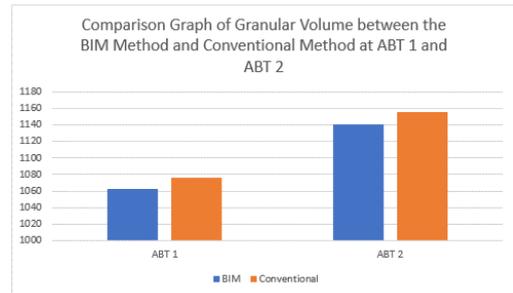
Figure 12. Concrete Volume deviation at ABT 1 – ABT 2

Figure 13. Granular Volume deviation at ABT 1 and ABT 2