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Cut and Fill Volume Planning in the Green Harmony Warakas Housing Project Using a Nikon DTM 322 Total Station and Autocad Civil 3D Software

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Abstract: Along with the increasing population growth, of course, the increase in needs will also increase significantly which will have an impact on the conversion of land functions into residential areas that are of course licensed and in accordance with government regulations. In this case, the Green Harmony Warakas housing developer as the land owner has plans to carry out development related to housing construction. However, in this housing development planning, the land that will be used for development has different heights so that it is necessary to plan the calculation of cut and fill volumes to determine which parts must be cut and filled in order to obtain a land surface in accordance with the previously planned plan. The problems that occur in the Green Harmony Warakas housing were chosen for research because they have problems related to cut and fill planning. The purpose of this research is to create a plan for calculating cut and fill volumes using AutoCAD Civil 3D software on the development land in the Green Harmony Warakas housing project. The cut and fill method is a method used to move excess material from one point to another with the aim of producing an even surface according to the existing plan. When planning cut and fill volume calculations, the required data is field measurement data, which will be processed into contour images. Then, calculations are performed based on the measurements to determine the volume of soil to be cut and filled.

Keywords: cut and fill, AutoCAD Civil 3D, Land contours, volume, Total Station.

INTRODUCTION

The increasing population in Indonesia has a direct impact on the surge in the need for residential infrastructure. Based on data from the Central Statistics Agency, the national population will increase from 281.60 million in 2024 to 284.43 million in 2025, with Banten Province as one of the regions with significant growth, reaching 12.5 million people [1]. This phenomenon triggers the conversion of agricultural land into residential areas. The characteristics of this transitional land often have uneven land contours, thus requiring precise topographic analysis before the construction phase begins to determine the elevation and dimensions of the land area. Cut and fill volume estimation is a critical parameter in construction project management. Errors in this volume calculation risk material inefficiency, operational cost overruns, and project schedule delays. This study focuses on optimizing soil volume calculations using the integration of the Nikon DTM 322 Total Station instrument and AutoCAD Civil 3D software. The implementation of this technology aims to produce accurate spatial data to support managerial decision making. The case study was conducted on the Green Harmony Warakas Housing Project which has complex land contour variability. Systematic cut and fill planning is expected to ensure

that the excavation and fill volumes are in accordance with the planned technical specifications.

LITERATUR REVIEW

MEASUREMENT

Measurement is a process of assigning numbers to certain attributes or characteristics of a person, thing, or object according to clear rules or formulations. [3]. Measurement (survey) is an activity of collecting data related to the earth's surface which is depicted in maps or digital form. Mapping surveys have a very important role and are needed in this era. From the results of the measurements, the topographic form of an area will be obtained, where this topographic form visualizes the slope of a land or land contour. [4]

CUT AND FILL

Cut is the process of creating a man-made cut or cavity in the earth's surface. cutting is necessary for construction projects such as water and sewer pipes, electrical line construction, foundation repair, and other structural work. cutting is the process of removing soil from one point to move it to another to level the ground surface. Before cut process begins, it have to be dewatering process, which is the process of removing or lowering the groundwater level or surface water from a construction, mining, or excavation work area to ensure the area remains dry and stable for work. Possible outcomes if errors occur during the foundation excavation process:

a. Irregular cut can affect subsequent stages
b. Incorrect cut elevations, such as too deep or too low, can impact the bearing capacity during soil testing.
c. cutting work carry the risk of landslides or falling debris. [5]

Fill is the process of moving soil from a location at a higher elevation to a lower elevation. This is done to achieve a more level surface, consistent with the established plan. Landfilling requires careful planning. The main factors to consider when designing an embankment are:

a) Fill stable
b) Fill bearing capacity
c) Fill settlement
d) trafficability[6]

So cut and fill is a term in construction work that is very important and even the main part of almost all types of construction to improve a sloping land so that the land can be level or improve the elevation[7]. Cut and fill is the process of moving earth where material is needed at one point to be filled and stored at another point. The cut and fill process aims to make the ground surface look level. [8]

PRINCIPLES OF SOIL VOLUME CALCULATION

Volume is a quantity used to measure the space of an object such as how much space can be filled or filled by an object. For example, in making foundations, excavations and embankments in irrigation plans, highways, railways, riverbanks, to calculate the volume of soil that must be excavated and disposed of elsewhere or vice versa. The first surface is usually the original ground surface or existing topography, while the second ground surface shows the planned ground surface or design of the excavation or embankment to be worked on. In determining the volume of cut and fill, the units commonly used are cubic feet (ft^3), cubic yards (yd^3) and cubic meters (m^3) for measuring

soil volume, although cubic yards are the most common units in earthworks $1yd^3 = 27\ ft^3$, $1\ m^3 = 35.315\ ft^3$. However, in Indonesia, the more commonly used is cubic meters (m^3) as a unit in determining the amount of volume.[9]

Total Station

A total station is a digital measuring instrument in the form of a modern optical instrument commonly used for surveying, mapping, and construction purposes. There are many types of total stations, one of which is the Nikon DTM 322. The Nikon DTM 322 is one brand of modern optical measuring instrument used for mapping. The following is an image of the Nikon DTM-322 total station.

Figure 1. Total Station Nikon DTM – 322[10]

The following are the specifications of total station by Nikon DTM – 322.

Table 1. spesification of total station by Nikon DTM - 322

DISTANCE MEASUREMENT	
Range with Nikon specified prisms	
Good conditions (No haze, visibility over 40 km (25 miles))	
With reflector sheet (5 × 5 cm)	1.5 m to 200 m (4.9 ft to 787 ft)
With single prism 6.25 cm (2.5 in)	3,000 m (9,840 ft)
Range reflectorless mode	
KGC (18%) 1	
Good	250 m (820 ft)
Normal	200 m (656 ft)
Difficult	150 m (492 ft)
KGC (90%)	
Good[1]	400 m (1312 ft)
Normal[2]	350 m (1148 ft)

Difficult[3]	250 m (820 ft)
Accuracy ISO 17123-4 (Precise mode)	
Prism 2	±(2+2 ppm × D) mm
Reflectorless/Reflector sheet 3	±(3+3 ppm × D) mm
Measuring interval 4	
Prism mode	
Precise mode	1.1 sec.
Normal mode	0.8 sec.
Reflectorless mode	
Precise mode	1.2 sec.
Normal mode	1.0 sec.
Least count	
Precise mode	1 mm (0.002 ft)
Normal mode	10 mm (0.02 ft)
ANGLE MEASUREMENT	
ISO 17123-3 accuracy (horizontal and vertical)	2“/0.6 mgon, 5“/1.5 mgon
Reading system	Photoelectric detection by incremental encoder
Circle diameter	88 mm (3.46 in)
Horizontal angle	2”:Diametrical, 5”:Single
Vertical angle	Single
Minimum increment (Degree, Gon, MIL6400)	1/5/10”, Gon: 0.2/1/2 mgon, MIL6400: 0.005/0.02/0.05 mil
TELESCOPE	
Tube length	125 mm (4.9 in)
Image	Erect

Magnification	30× (18x/36x with optional eyepieces)
Effective diameter of objective	45 mm (1.77in)
EDM Diameter	50 mm (1.97 in)
Field of view	1°20‘
Resolving power	3”
Minimum focusing distance	1.5 m (4.9 ft)
Laser Pointer	Coaxial Red Light
TILT SENSOR	
Type	Dual axis
Method	Liquid-electric detection
Compensation range	±3‘
COMMUNICATIONS	
Communication ports	1 x serial (RS-232C)
WIRELESS COMMUNICATIONS	
Bluetooth	Integrated
GENERAL SPECIFICATIONS	
Level vials	
Sensitivity of Plate level vial	30“/2 mm
Sensitivity of Circular level vial	10‘/2 mm
Optical plummet	
Image	Erect
Magnification	3X
Field of view	5°
Focusing range	0.5 m (1.6 ft) to ∞
Display	
2“	Both sides, backlit, graphic LCD (128 × 64 pixel)

5“	Single side, backlit, graphic LCD (128 × 64 pixel)
Point memory	50,000 records
Dimensions (W x D x H)	168 mm x 173 mm x 335 mm (6.6 in x 6.8 in x 13.1 in)
Weight (approx.)	
Main unit (without battery)	4.9 kg (10.8 lb)
Battery	0.1 kg (0.2 lb)
Carrying case	2.5 kg (5.5 lb)
Dual charger and AC adaptor	0.6 kg (1.3 lb)
Power	
Clip-on Li-on battery	x^2 incl.
Operating time 5 (per battery)	
Continuous distance/angle measurement	approx. 4.5 hours
Distance/angle measurement every 30 seconds	approx. 11 hours
Continuous angle measurement	approx. 22 hours
Charging time	
Full charge	4 hours
External power supply	N/A
ENVIRONMENTAL	
Ambient temperature range	–20 °C to +50 °C (–4 °F to +122 °F)
Atmospheric correction	
Temperature range	–40 °C to +60 °C (–40 °F to +140 °F)
Barometric pressure	400 mmHg to 999 mmHg/533 hPa to 1,332 hPa/15.8 inHg to 39.3 inHg
Dust and water protection	IP55
CERTIFICATION	

Class B Part 15 FCC certification, CE Mark approval.	
IEC60825-1:2007	
Reflectorless mode	Class 1
Laser Pointer	Class 2
Prism mode	Class 1

Autocad Civil 3D

AutoCAD Civil 3D is a one of product that developed by AutoDesk.this product was developed by a multinational company at California and the founded are Jhon Walker and Drake[10]. AutoCAD Civil 3D is a dynamic, easy-to-use, and innovative software used for designing buildings, roads, and other industrial products. AutoCAD Civil 3D is an application commonly used by civil engineering professionals to design and plan construction and engineering projects, including harbor and dam construction. [11]
AutoCAD Civil 3D is an intelligent, 3D-based design program (part of the Building Information Modeling (BIM) concept) that dynamically calculates design changes. [12]
Some of the key features of AutoCAD Civil 3D include:

a) Creation and processing of contour and ground surface data.
b) Creation of Digital Terrain Models (DTMs).
c) Automatic cut and fill analysis and visualization of the results.
d) Integration with survey and mapping data.

This software greatly simplifies calculations and drawings previously performed manually, thereby increasing accuracy and efficiency in civil engineering work.

RESEARCH METHOD

The research method used in this finall project is quantitative descriptive because the data presented with numerical and uses a direct approach. The research data was obtained from observations in the form of land measurements..

Research Type

This research is a terrestrial survey or terrestrial measurement. It focuses on collecting field data using a total station to obtain topographic data for a plot of land. The data obtained will be processed using AutoCAD Civil 3D software to obtain information regarding the contours of the plot, which will then be used to calculate the planned cut and fill volumes for the housing project. The results of these calculations will be described to provide an understanding or overview of optimal earthwork planning..

Data Type and Sources

In this research, the data used is devided into 2 categories, including :

1. **Primery Data**
   Primary data is data obtained directly, including :
   a. Measurement data from a total station
   b. Flood level elevation data from the Public Works and Public Housing Agency
2. **Secondary Data**
   Secondary Data that used to this research is detailed map from Binuang Village
3. **Data Collection Technique**

In this research, research data collection was carried out using several techniques, including :

1. Documentation
   Collect all the required data in the form of documentation results during the project.
2. Survey
   Data obtained directly from the field, such as measurement data, benchmarks, etc.

4. **Flowchart**

In this research, there are stages for collecting and processing data, commonly referred to as the flow process. The following are the stages.:

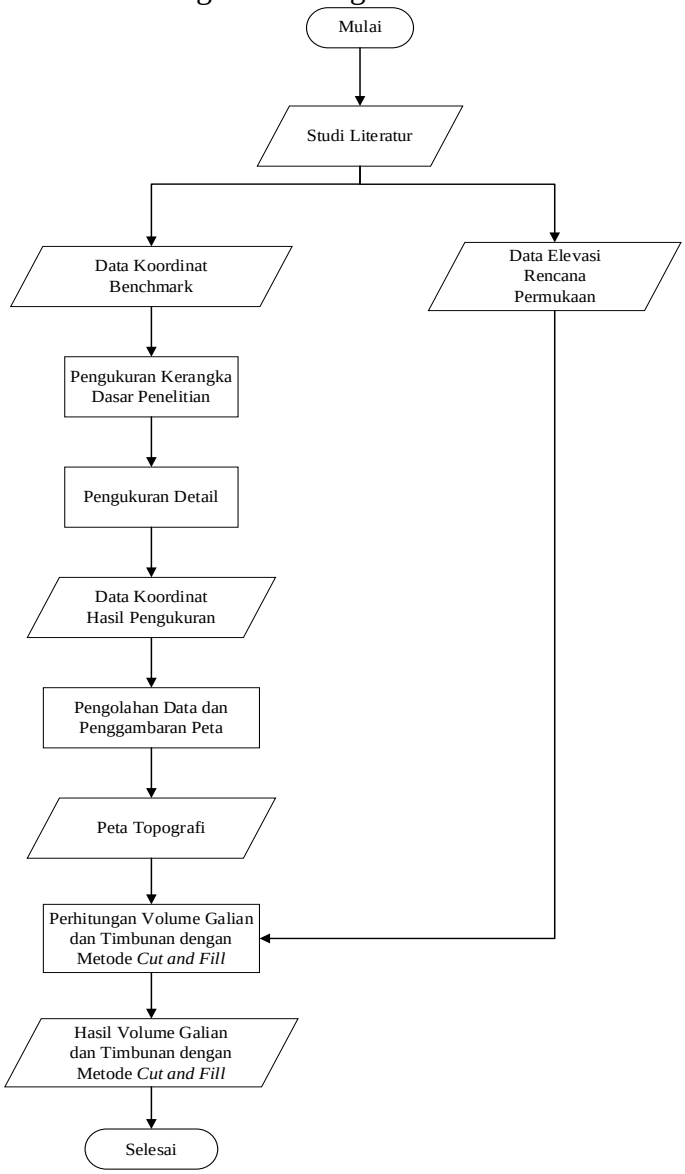

Figure 2. Flowchart of design Cut and Fill

5. **Data Collection**

To determine the contour and volume of land that can be cut and fill, measurements are required. This requires tools such as a total station, measuring tape, a tripod, point

targets, and a prism pole. In addition, a detailed map is also needed to provide information on the land to be measured. The following is the measurement data.

Table 2. Data coordinat XYZ

POINT	NORTHING (Y)	EASTING (X)	ELEVATION (Z)	DESKRIPSI
1	1104.635	976.826	101.544	BATAS
2	1103.984	987.674	101.479	BATAS
3	1103.283	998.371	101.572	BATAS
4	1083.325	997.742	101.421	MAUN
5	1085.233	987.852	101.01	MAUN
6	1084.662	986.902	101.199	MAUN
7	1086.932	977.204	101.114	MAUN
8	1086.809	975.711	100.691	BATAS
9	1075.507	974.183	100.55	BATAS
10	1066.052	974.644	100.453	POJOK
11	1064.715	981.285	100.417	POJOK
12	1062.874	986.284	100.564	POJOK
13	1064.57	986.906	100.819	POJOK
14	1074.386	987.749	100.907	POJOK
15	1084.711	986.989	101.222	POJOK
16	1083.246	997.915	101.424	BUAH
17	1081.415	1003.972	101.457	BUAH
18	1071.231	1004.415	101.292	BUAH
19	1061.338	1003.19	101.378	BUAH
20	1062.668	999.669	100.847	BUAH
21	1064.582	986.85	100.811	BUAH
22	1062.731	986.067	100.566	KARBA
23	1048.826	985.675	100.488	KARBA
24	1028.091	987.897	100.547	KARBA
25	1026.93	998.195	100.449	KARBA
26	1026.758	1005.055	100.857	KARBA
27	1038.984	1003.075	100.912	KARBA
28	1052.609	1003.865	101.046	KARBA
29	1053.838	1004.315	101.234	KARBA
30	1061.187	1003.097	101.388	KARBA
31	1062.838	985.902	100.573	BUANG
32	1065.078	979.59	100.387	BUANG
33	1065.977	974.76	100.459	BUANG
34	1065.122	973.183	100.422	BUANG
35	1058.304	972	100.411	BATAS
36	1026.551	973.618	100.145	BATAS
37	1025.164	986.838	100.246	BUANG
38	1028.007	987.913	100.535	BUANG
39	1047.256	985.694	100.49	BUANG
40	1027.992	987.884	100.519	JEN

To calculate the cut and fill volume, software is required to ensure more accurate calculations, and one of the software that can be used is AutoCAD Civil 3D.

Result and Discussion

Data coordinate must be input to AutoCAD Civil 3D, the data will appear in the form of dots like that picture

Figure 3. coordinat dots of XYZ

Next, these points will be processed to form a line image that forms lowlands and highlands as in the following image.

Figure 4. contour of land

From the data obtained from table 2, calculations were carried out using AutoCAD Civil 3D to determine size of the cut and fill volume. The following are the results of the cut and fill volume calculations using AutoCAD Civil 3D.

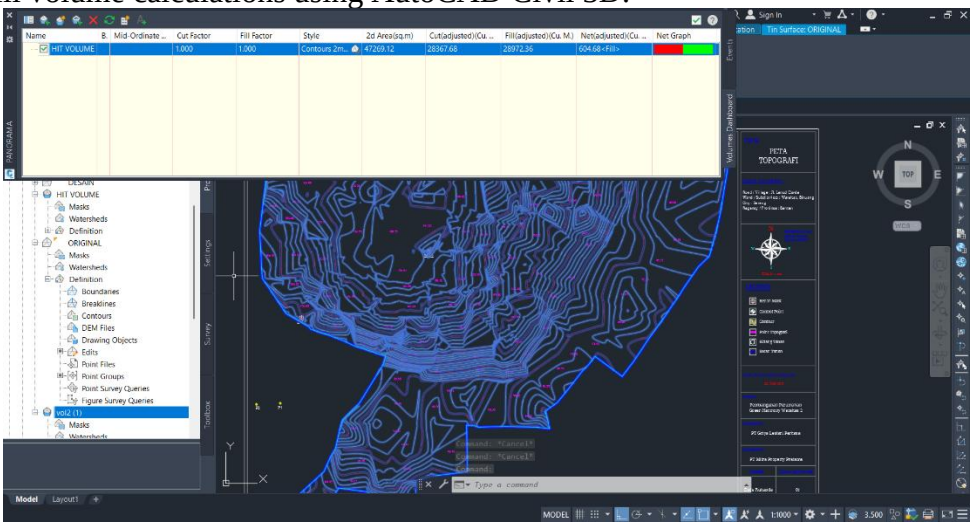

Figure 5. determine Volume Cut and Fill with AutoCAD Civil 3D

and the result cut volume of 28.368 m3 and fill volume of 28.972 m3 with nett of 605 m3 (fill)

CONCLUSION AND RECOMENDATIONS

Conclution

Based on the calculation results using AutoCAD Civil 3D, the following conclusions can be drawn :

a. The land measurement method using a Nikon DTM 322 Total Station begins with adjusting the equipment to meet existing requirements, followed by taking points on each plot of land according to the existing detailed map.
b. After inputting field measurement data into AutoCAD Civil 3D software, a land contour image for the Green Harmony Warakas housing project was obtained. The contour data depicts high and lowland areas. After data input, the volume required to be cut and filled was determined to ensure the land surface conforms to the design.
c. After calculations using AutoCAD Civil 3D software and manual calculations, the total cut volume was 28,367 m^3 and the fill volume was 28,972 m^3, with a cut-to-fill difference of 605 m^3 (fill), with a fill elevation of 99.955

Recomendations

After carrying out the research process, there are several suggestions that can be used as considerations, including:

1. It is recommended to take closer measurements to ensure more accurate data collection due to the varied terrain at the Green Harmony Warakas housing project.
2. This research is expected to provide a reference and overview for cut-and-fill work, ensuring the project's development plan can proceed effectively and efficiently

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