Precision Land Surveying: Advancing Accuracy with Differential GPS Technology

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Abstract - *Land surveying is a cornerstone of infrastructure development, construction, and land management, but traditional methods often come with challenges like lengthy fieldwork, time-consuming processes, and the risk of human error. To address these issues, this study dives into the potential of Differential Global Positioning System (DGPS) technology as a game-changer for land surveying. DGPS offers highly accurate geospatial data, slashing errors and speeding up data collection compared to older methods. In this research, a DGPS device was used to survey a specific plot of land. The data collected was then processed to create a detailed site plan using AutoCAD, bringing the survey to life in a digital format. To further understand the terrain, a contour map of the plot was generated using Esurvey CAD software. This map not only provided a clear visual of the land's elevation changes but also helped in calculating earthwork needed for leveling the site. The findings highlight how DGPS-based surveying can revolutionize the field, offering a faster, more accurate, and efficient way to gather and process land data. This makes it an invaluable tool for engineers, construction teams, and land managers, streamlining projects and reducing the margin for error. By embracing this technology, the future of land surveying looks not only more precise but also more manageable and less labor-intensive.*

***Key Words*: DGPS, Land Surveying, AutoCAD, Esurvey CAD, Contour Mapping, Earthwork Calculation, Accuracy, Speed, Efficiency**

1. INTRODUCTION

Land surveying is a vital part of civil engineering, construction, and land development, providing the critical geospatial data needed for planning sites and calculating earthwork. Traditional methods, like using a total station or leveling equipment, often demand a lot of time and effort, and they're not immune to human error. To tackle these challenges, newer technologies like the Differential Global Positioning System (DGPS) have become increasingly popular.

DGPS is a high-precision tool that builds on standard GPS by using correction signals from reference stations, boosting accuracy and reliability. This makes data collection faster and more dependable, streamlining the entire surveying process. In this study, a DGPS device was used to survey a specific plot of land. The data gathered was then processed to create a detailed site plan using AutoCAD, and a contour map was generated with Esurvey CAD software to show elevation changes and help with earthwork calculations.

The main goal of this research is to show how DGPS-based surveying can improve accuracy, save time, and make the whole process simpler and more user-friendly. By combining DGPS technology with advanced software for data processing, this approach offers a smarter, more efficient way to measure land and analyze terrain, especially for projects that need precise earthwork planning. It's a step forward in making surveying more accessible and effective for professionals in the field.

2. NEED FOR LAND SURVEYING

Accurate land surveying is a cornerstone of engineering and construction projects, providing the vital data needed for site planning, earthwork calculations, and infrastructure development. Traditional methods, like using total stations or leveling instruments, often come with their own set of challenges they're time-consuming, labor-intensive, and prone to human error. These issues can lead to inaccuracies in measurements, which not only slow down projects but also drive up costs.

To tackle these problems, the use of Differential Global Positioning System (DGPS) technology has become a game-changer in land surveying. DGPS takes standard GPS to the next level by using real-time corrections from reference stations, delivering much more precise positioning data. This not only boosts the reliability of survey measurements but also cuts down significantly on the time spent in the field.

In this study, DGPS was used to survey a specific plot of land. The data collected was then processed to create a detailed site plan using AutoCAD. To better understand the terrain, a contour map was also generated using Esurvey CAD software, helping to visualize elevation changes and making earthwork calculations easier. This project was born out of the growing need for faster, more accurate, and efficient surveying methods that reduce errors and simplify project planning. By combining DGPS with advanced software tools, this approach offers a modern, practical solution for land measurement, making it especially valuable for engineering and construction projects. It's a step toward making surveying more precise, efficient, and accessible for professionals in the field.

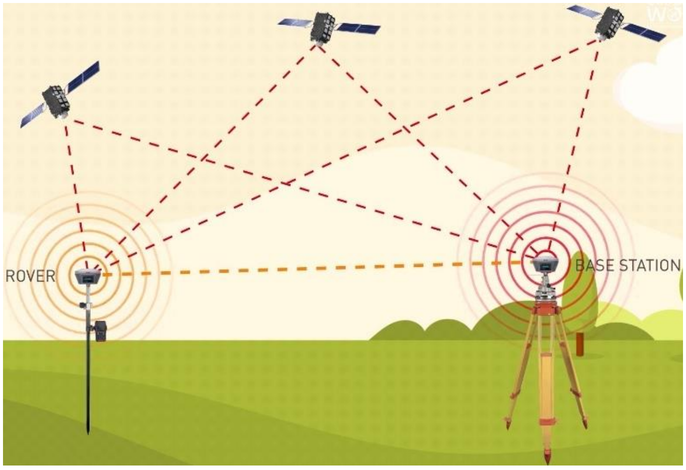

Fig -1: Representation of working principle of DGPS (Source: Google.com)

3. OBJECTIVES

- To make land surveying more accurate and reliable
- To save time and work smarter
- To make surveying easier and more user-friendly
- To create a clear and detailed site plan
- To map out the terrain and understand elevation changes
- To help plan and design earthwork with confidence
- To show how DGPS-based surveying can be a game-changer

4. METHODOLOGY

4.1 Surveying with DGPS

4.1.1 Description of EFIX F4 and F7 DGPS Instrument

The EFIX F4 and F7 are cutting-edge GNSS (Global Navigation Satellite System) receivers built to deliver high-precision results for land surveying tasks. These devices are designed to work seamlessly with multiple satellite systems, including GPS, GLONASS, Galileo, and BeiDou, ensuring reliable and accurate positioning data even in tough environments like dense urban areas or remote locations. Whether you're working on a construction site, mapping out terrain, or planning infrastructure, these receivers are built to keep up with your needs.

One of the standout features of these models is their ability to connect with multiple satellite constellations. They can track signals from GPS (L1, L2, L5), Galileo (E1, E5a, E5b), and BeiDou (B1, B2, B3), which means you'll always have strong satellite visibility and pinpoint accuracy, no matter where you are. With an impressive 824 channels, they can handle multiple satellite signals at once, ensuring your data is both reliable and precise.

Another game-changing feature is the built-in Inertial Measurement Unit (IMU), which allows for tilt compensation of up to 60 degrees. This means you don't have to worry about keeping the pole perfectly vertical even if it's slightly tilted, you'll still get accurate readings. Plus, these devices are built to last. With an IP67 rating, they're dustproof and waterproof, making them perfect for tough field conditions, whether you're working in the rain or on a dusty construction site. And despite their rugged design, they're surprisingly lightweight the EFIX F4, for example, weighs just 0.77 kg, so you can carry it around all day without feeling weighed down.

Fig -2: Efix F4 F7 DGPS instrument (Source: Google.com)

4.1.2 Setup Process and Data Collection Technique

Step 1 - Equipment Preparation

Before heading out, make sure everything is ready to go. Start by checking the EFIX F4/F7 receiver, ensure it's fully charged and functioning properly. Depending on your survey needs, mount the receiver on either a stable tripod or a survey pole for mobility. Don't forget to attach the UHF antenna to the receiver, this is crucial for smooth communication between the base and rover units.

Step 2 - Base Station Setup

The base station is your anchor point, so it's important to set it up correctly. Begin by securely mounting the **EFIX F4 receiver** on a tripod at a known reference point. Make sure the setup is stable and the receiver is perfectly level. Turn on the device by pressing and holding the power button until the indicators light up. Next, use the field software to configure the receiver to operate in **base mode**. Set the communication parameters, like frequency and protocol, to match the rover unit. This ensures seamless communication between the two devices.

Step 3 - Rover Station Setup

The rover is your mobile unit, so it needs to be ready for action. Attach the **EFIX F7 receiver** to a survey pole and double check that the **UHF antenna** is properly connected. Power it on by pressing the power button until the indicators come to life. Then, open the field software on your controller device (like a tablet or handheld computer) and connect it to the rover receiver. Configure the rover to operate in **rover mode**, making sure the communication settings align with the base station. This step ensures everything is synced and ready for data collection.

Step 4 - Data Collection

Now comes the exciting part, collecting the data First, wait for the rover receiver to achieve a **fixed solution**, which means it's locked onto the satellite signals and ready to provide reliable positioning data. Once that's done, start surveying by using the field software to collect data points. Thanks to the **IMU integration**, you don't have to worry about keeping the pole perfectly vertical, it can tilt up to 60 degrees and still deliver accurate results. As you collect data, it's stored internally on the device. Later, you can export it for post-processing or use it directly in software like **AutoCAD** or **Esurvey CAD** to create detailed site plans or contour maps.

Fig -3: Data Obtained after Survey

Table -1: Readings Taken using DGPS

Sr. No	Marking	Northing	Easting	Elevation
1	Boundary	1107875	681452	24.74
2	Boundary	1107874	681461	24.7
3	Boundary	1107873	681473	26.08
4	Boundary	1107871	681482	26.609
5	Boundary	1107870	681492	27.592
6	Boundary	1107869	681497	27.991
7	Boundary	1107869	681502	27.775
8	Boundary	1107868	681508	27.833
9	Boundary	1107868	681510	28.028
10	Boundary	1107867	681517	28.123
11	Boundary	1107866	681523	28.305
12	Boundary	1107865	681534	28.713
13	Boundary	1107864	681542	29.247
14	Boundary	1107863	681551	30.096
15	Boundary	1107863	681554	30.063
16	Boundary	1107862	681558	30.698
17	Boundary	1107862	681563	31.081
18	Boundary	1107861	681566	31.225
19	Boundary	1107861	681573	31.728
20	Boundary	1107860	681585	31.904
21	Boundary	1107859	681596	31.915
22	Boundary	1107859	681598	32.297
23	Boundary	1107857	681602	32.164

24	Boundary	1107853	681602	32.609
25	Boundary	1107847	681601	33.07
26	Boundary	1107844	681601	33.408
27	Boundary	1107841	681601	33.24
28	Boundary	1107834	681600	34.029
29	Boundary	1107828	681599	34.178
30	Boundary	1107816	681596	35.766
31	Boundary	1107808	681593	36.107
32	Boundary	1107799	681590	36.369
33	Boundary	1107793	681588	36.317
34	Boundary	1107790	681587	36.434
35	Boundary	1107787	681586	36.459
36	Boundary	1107781	681584	36.449
37	Boundary	1107779	681584	35.995
38	Boundary	1107775	681582	36.096
39	Boundary	1107773	681581	36.068
40	Boundary	1107766	681589	35.461
41	Boundary	1107764	681586	35.648
42	Boundary	1107756	681580	34.185
43	Boundary	1107751	681576	32.637
44	Boundary	1107745	681570	30.437
45	Boundary	1107743	681569	29.746
46	Boundary	1107738	681565	28.31
47	Boundary	1107733	681560	27.036
48	Boundary	1107729	681556	25.316
49	Boundary	1107724	681552	23.263
50	Boundary	1107721	681549	22.174
51	Boundary	1107721	681548	21.255
52	Boundary	1107729	681541	20.307
53	Boundary	1107732	681539	20.789
54	Boundary	1107738	681536	20.886
55	Boundary	1107746	681530	21.171
56	Boundary	1107755	681523	20.982
57	Boundary	1107764	681513	21.364
58	Boundary	1107777	681501	22.75
59	Boundary	1107782	681496	22.869
60	Boundary	1107780	681497	22.045
61	Boundary	1107785	681491	22.586
62	Boundary	1107789	681487	21.379
63	Boundary	1107791	681483	20.65
64	Boundary	1107792	681479	21.081
65	Boundary	1107796	681475	21.008
66	Boundary	1107803	681464	21.157
67	Boundary	1107805	681458	21.325

68	Boundary	1107808	681453	21.087
69	Boundary	1107812	681445	20.932
70	Boundary	1107816	681438	21.057
71	Boundary	1107820	681431	21.453
72	Boundary	1107825	681425	21.47
73	Boundary	1107829	681420	21.576
74	Boundary	1107836	681416	21.695
75	Boundary	1107840	681413	22.261
76	Boundary	1107844	681420	23.129
77	Boundary	1107848	681426	23.773
78	Boundary	1107854	681434	24.927
79	Boundary	1107856	681436	25.314
80	Boundary	1107858	681439	25.968
81	Boundary	1107863	681443	26.236
82	Boundary	1107865	681445	26.142
83	Boundary	1107870	681449	25.723
90	Road	1107818	681401	21.962
91	Road	1107819	681395	22.007
93	Road	1107837	681402	22.126
100	Road	1107862	681432	24.479
102	Road	1107877	681443	24.525
104	Road	1107897	681443	25.24
105	Road	1107916	681441	25.581
106	Road	1107907	681450	25.355

4.2 Site Plan Preparation in AutoCAD

Once you've collected your DGPS survey data, the next step is to turn it into a clear and professional site plan using AutoCAD. Here's a step-by-step guide to help you through the process:

Step 1 - Export Survey Data

Start by connecting your DGPS device to a computer and downloading the collected data. Save it in a **CSV** (Comma-Separated Values) or **TXT** format for easy processing. Make sure the data includes all the essential details like **Point ID**, **Easting (X)**, **Northing (Y)**, **Elevation (Z)**, and **Description.** This information is the foundation of your site plan, so double-check that everything is accurate and complete.

Step 2 - Open AutoCAD and Set the Correct Units

Launch AutoCAD and create a new drawing file. Before you start, set the correct units to match your survey data. Type **"UNITS"** in the command bar and choose the appropriate unit (meters or feet). If your project requires a specific coordinate system, set that up now as well.

Step 3 - Import Data Automatically

If your DGPS data is in CSV format, you can use the **"DATAEXTRACTION"** command or a custom script to import it into AutoCAD. Alternatively, you can use the **"IMPORT"** tool or the **"Survey Database"** feature (available in some versions of AutoCAD) to bring in the survey data in bulk. This step saves time and ensures all your points are accurately placed in the drawing.

Step 4 - Connecting Survey Points to Form a Site Layout

Now it's time to connect the dots, use the **"PLINE"** or **"POLYGON"** to link boundary points based on their descriptions. Draw property lines, roads, and other key features using the survey data as your guide. This step helps you visualize the layout of the site.

Step 5 - Add Labels to Survey Points

To make your site plan easy to read, label each survey point with it's **Point ID** or **Elevation.** Use the **"TEXT"** or **"MTEXT"** command to add these labels. This way, anyone looking at the plan can quickly identify specific points and their details.

Step 6 -Draw Existing Features (Buildings, Roads, Utilities, etc.)

Next, add existing structures and features to the plan. Use commands like **"LINE," "ARC,"** and **"CIRCLE"** to represent buildings, roads, utilities, and other important elements. Organize these features into separate layers to keep your drawing clean and easy to navigate.

Step 7 - Adjust Layer Properties

Open the **Layer Manager** (type **"LA"** in the command bar) and assign different layers for boundaries, text, and survey points. Use colours and line types to differentiate between elements. For example, you might use a bold line for property boundaries and a dashed line for utilities. This step makes your site plan more visually appealing and easier to understand.

Step 8 - Finalizing the Site Plan

To wrap up, fine-tune your site plan for clarity and professionalism. Adjust **line weights** and **colors** to highlight key elements and improve readability. Once you're happy with the result, save the file in **DWG format** for future edits or export it as a **PDF** for sharing and documentation.

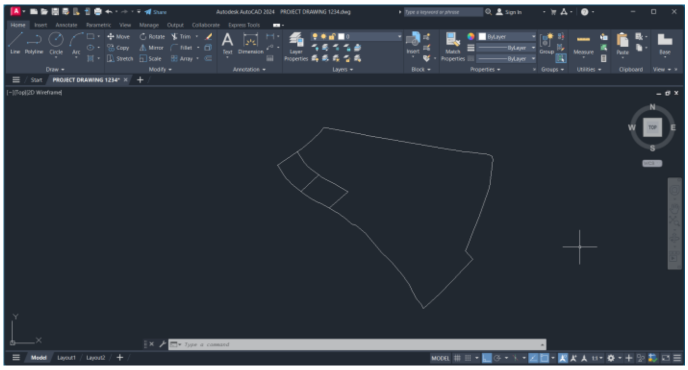

Fig -4: Site Boundary Prepared in AutoCAD

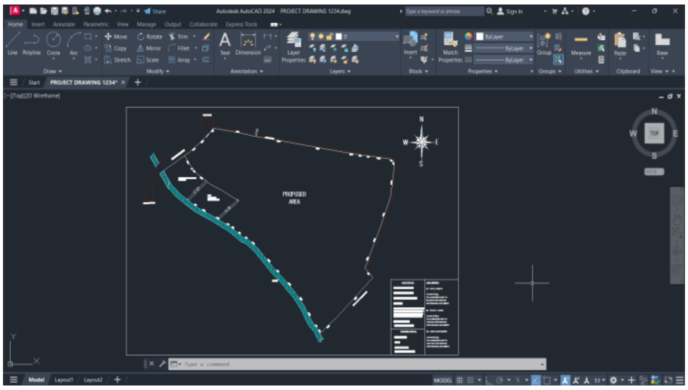

Fig -5: Site Plan Prepared in AutoCAD

4.3 Contour Map Preparation in Esurvey CAD

A contour map is a powerful tool that shows elevation changes across a site, making it essential for tasks like earthwork calculations, drainage planning, and terrain analysis. Esurvey CAD is a user-friendly software designed specifically for creating contour maps from survey data. Here's a step-by-step guide to help you generate a contour map using DGPS data:

Step 1 - Export DGPS Data

Start by connecting your DGPS device to a computer and extracting the surveyed data. Save the data in CSV (Comma-Separated Values) or TXT format, ensuring it includes columns for Point ID, X, Y, and Z coordinates. This data will serve as the foundation for your contour map.

Step 2 - Launch Esurvey CAD and Open a New Drawing

Open Esurvey CAD, either as a standalone software or as a plugin within AutoCAD. Create a new drawing file to begin working on your contour map**.**

Step 3 - Import Survey Data

Navigate to the Contour Module and select Import Points. Choose the CSV or TXT file containing your DGPS survey points and click Open. Verify that all the points are displayed correctly on the screen.

Step 4 - Define Contour Intervals

Set the contour interval based on the needs of your project. For example, you might choose **0.5m** for detailed work or **1m** or **2m** for larger sites. Enter the interval in the **Contour Settings** under **Contour Interval**.

Step 5 - Create the Contour Surface

Click on **Generate Contours** to create a **Triangulated Irregular Network (TIN Surface)** from the survey points. The software will automatically interpolate elevation changes and generate smooth, accurate contour lines.

Step 6 - Modify Contour Display (Optional)

If needed, adjust the **smoothing settings** to refine the curves of the contour lines. You can also customize the **line thickness** and **colors** for major and minor contours to make the map easier to read.

Step 7 - Labelling Contours

Use the **Annotate → Label Contours** tool to add elevation values to the contour lines. Adjust the **font size** and **placement** to ensure the labels are clear and readable.

Step 8 - Adding Boundary & Features

If you have additional data like site boundaries, roads, or water bodies, you can import them using **DXF** or **DWG files**. Use tools like **Polyline** or **Boundary Line** to overlay these features onto the contour map, giving it more context and detail.

Step 9 - Save and Export the Contour Map

Once your contour map is complete, save the drawing in **DWG** (AutoCAD format) or **DWT** (Esurvey CAD format) for future edits. If you need to share the map or include it in a report, export it as a **PDF** or **JPEG** file.

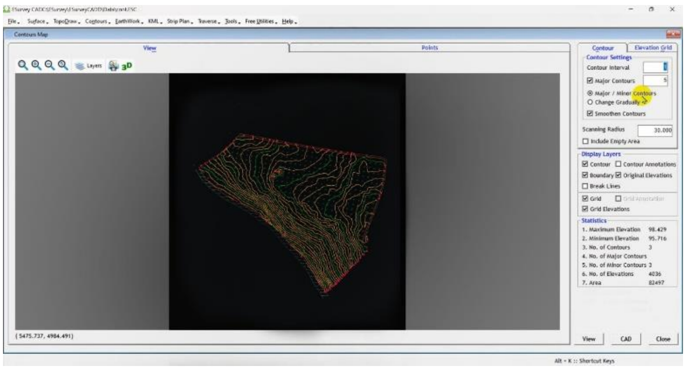

Fig -6: Contour Map Prepared in Esurvey CAD

5. RESULTS AND DISCUSSIONS

5.1 Accuracy Improvement with DGPS

When it comes to land surveying, accuracy, time, and effort are critical factors. The introduction of DGPS (Differential Global Positioning System) technology has brought significant improvements over traditional surveying methods. Here's a quick comparison to highlight the differences:

Table -2: Comparison of DGPS results with traditional methods

Parameter	Traditional Survey	DGPS Survey
Accuracy (m)	±0.5	±0.02
Time Required (hrs)	10	4
Human Effort	High	Low

As shown in the table, DGPS delivers a remarkable leap in **accuracy**, reducing errors from **±0.5 meters** to just **±0.02 meters**. This level of precision is especially valuable for projects where even small errors can lead to big problems.

In terms of **time**, DGPS cuts down surveying hours from **10 hours** to just **4 hours**. This means projects can move forward faster, saving both time and resources.

Finally, the **human effort** required is significantly reduced. Traditional methods often involve labor-intensive processes, while DGPS simplifies the workflow, making it easier for surveyors to collect data efficiently.

5.2 Site Plan Output

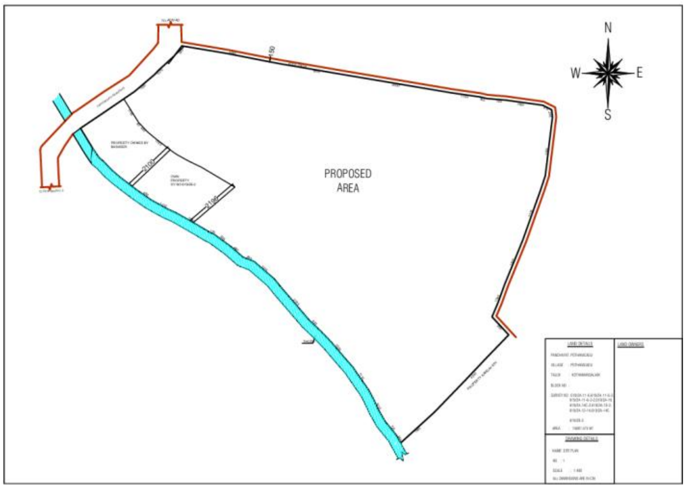

Fig -7: AutoCAD-generated drawing of the surveyed plot

5.3 Contour Map Output

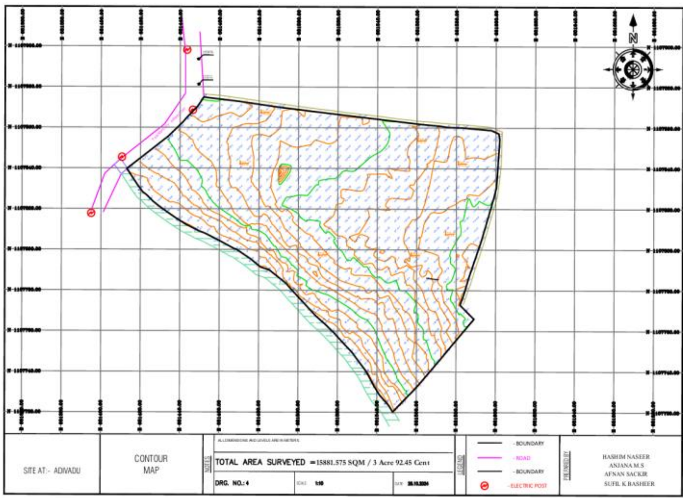

Fig -8: Esurvey CAD contour map visualization

5.4 Earthwork Calculation Analysis

Volume Report Between Initial Level and Formation Level

Sl. No.	Section From	Previous Section	Difference	Width	Cutting Volume				Filling Volume			
					Area Sq. Mtrs	Previous Area	Average Sq. Mtrs	Volume Cubic Meters	Area Sq. Mtrs	Previous Area	Average Sq. Mtrs	Volume Cubic Meters
1	0.000	-	0.000	45.010	137.765	0.000	68.883	0.000	0.000	0.000	0.000	0.000
2	10.000	0.000	10.000	55.670	163.946	137.765	150.856	1508.555	0.000	0.000	0.000	0.000
3	17.420	10.000	7.420	91.210	339.704	163.946	251.825	1868.542	0.000	0.000	0.000	0.000
4	20.000	17.420	2.580	91.660	324.549	339.704	332.127	856.886	0.000	0.000	0.000	0.000
5	23.420	20.000	3.420	92.260	299.757	324.549	312.153	1067.563	0.000	0.000	0.000	0.000
6	23.670	23.420	0.250	57.200	311.634	299.757	305.696	76.424	0.000	0.000	0.000	0.000
7	30.000	23.670	6.330	93.490	392.674	311.634	352.154	2229.135	0.000	0.000	0.000	0.000
8	40.000	30.000	10.000	95.350	293.962	392.674	343.318	3433.180	5.554	0.000	2.777	27.770
9	50.000	40.000	10.000	97.220	250.198	293.962	272.080	2720.800	22.040	5.554	13.797	137.970
10	60.000	50.000	10.000	99.080	206.542	250.198	228.370	2283.700	43.973	22.040	33.007	330.065
11	70.000	60.000	10.000	100.940	161.665	206.542	184.104	1841.035	76.051	43.973	60.012	600.120
12	80.000	70.000	10.000	97.040	116.841	161.665	139.253	1392.530	68.988	76.051	72.520	725.195
13	90.000	80.000	10.000	88.850	87.825	116.841	102.333	1023.330	65.117	68.988	67.053	670.525
14	100.000	90.000	10.000	81.860	72.594	87.825	80.210	802.095	75.001	65.117	70.059	700.590
15	110.000	100.000	10.000	77.740	19.863	72.594	46.229	462.285	104.290	75.001	89.646	896.455
16	120.000	110.000	10.000	72.640	3.958	19.863	11.911	119.105	111.558	104.290	107.924	1079.240
17	130.000	120.000	10.000	69.180	3.763	3.958	3.861	38.605	148.382	111.558	129.970	1299.700
18	140.000	130.000	10.000	65.850	3.492	3.763	3.628	36.275	185.616	148.382	166.999	1669.990
19	150.000	140.000	10.000	56.750	0.000	3.492	1.746	17.460	200.282	185.616	192.949	1929.490
20	160.000	150.000	10.000	38.790	0.000	0.000	0.000	0.000	174.474	200.282	187.378	1873.780
21	170.000	160.000	10.000	22.070	0.000	0.000	0.000	0.000	118.704	174.474	146.589	1465.890
22	177.830	170.000	7.830	6.790	0.000	0.000	0.000	0.000	39.007	118.704	78.856	617.439
					Total			**21777.505**				**14024.219**

Fig -9: Example for Earthwork Excavation output from Esurvey CAD

6. CONCLUSIONS

The use of DGPS-based land surveying has proven to be a game-changer, bringing significant improvements in accuracy, efficiency, and overall ease of surveying operations. By leveraging advanced tools like the **EFIX F4 and F7 DGPS instruments**, we were able to collect highly precise geospatial data, drastically reducing the errors often associated with traditional surveying methods.

The **AutoCAD-based site plan** provided a clear and detailed representation of the surveyed plot, ensuring accurate land assessment and effective planning. Meanwhile, the **Esurvey CAD-generated contour map** offered a visual understanding of terrain elevations, which is essential for earthwork calculations like cutting and filling.

This integrated approach not only speed up data collection but also simplified post-processing, making the entire surveying process more efficient and reliable. The project underscores the value of embracing modern surveying technologies to optimize land development projects, reduce human errors, and support better decision-making in civil engineering applications.

REFERENCES

[1] Alabi A.O, Alademomi A.S, Salami T.J, Okutubo A.D and Oyedokun W.R, "Accuracy assessment of established controls for precise positioning using DGPS and CORS," Science, vol.8, Mar,2024pp,0.1-12 doi:10.36263/nijest. 2024.01.01.

[2] Ammar jasim dakhil, Mustafa shareef, and Ihsan Qasim"Assessment of positioning accuracy using DGPS in Iraqi survey work," tqujes, Vol 11.2, Apr 2021ppdoi: 10.31663/tqujes.11.2.401.

[3] Debjyoti ghosh, Ashvini kumar, Abhishek kumar Yadav, Suresh kannaujiya and Pareshnath singha roy"surface deformation monitoring of Raniganj coalfield, India, using advanced InSAR and DGPS," Geomatics, Nat. Hazards Risk, vol 15,Jul pp doi: 10.1080/19475705. 2024.2375546.

[4] Didigwu, and Augustus Ugonna Sunday"Comparative study of differential global positioning system (DGPS) and conventional survey methods of coordinates determination," arejoen ,vol4(I),Mar2021 pp doi: 10.36265/ arejoen.2021. 010110.