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GIS – Enabled Residential Layout Design and Quantity Estimation using Civil 3D

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Abstract: *This project outlines a comprehensive, technology-driven approach to land development planning, combining advanced surveying methods, geospatial data analysis, and civil engineering design. Focusing on a 4082.451 m² parcel of land within the CJITS campus, the study aims to transform the area into a well-structured residential layout in compliance with Directorate of Town and Country Planning (DTCP) standards.The methodology integrates drone-based aerial surveying and Differential Global Positioning System (DGPS) for precise topographical data acquisition. This high-resolution spatial data was processed using Geographic Information Systems (GIS) tools and imported into AutoCAD Civil 3D for detailed design and drafting.*

The planning phase involved the creation of an efficient road network, allocation of residential plots, demarcation of open spaces, provision for utility infrastructure, and inclusion of designated green zones. A uniform and regulation-compliant residential building plan was applied to all plots to maintain consistency in development. Furthermore, the project includes a comprehensive quantity estimation of materials and resources needed for implementation.

By leveraging terrain modeling, civil design software, and urban planning principles, this project demonstrates a real-world engineering solution that is both practical and scalable. It serves as a model for smart and sustainable land development that aligns with current urban planning guidelines and technological trends..

Keywords: land development

I. INTRODUCTION

Land development and urban infrastructure planning are critical components of civil engineering that directly impact the sustainability, accessibility, and quality of life in urban and semi-urban areas. Traditionally, land development planning relied on time-consuming manual surveys and 2D planning tools. However, with the advent of cutting-edge geospatial technologies such as UAV (Unmanned Aerial Vehicle) drone photogrammetry, Differential Global Positioning System (DGPS), and Building Information Modeling (BIM), the planning and design process has become more efficient, accurate, and data-driven. This project utilizes these advanced tools to carry out a detailed land development project in a selected part of the CJITS campus, Jangaon 506167.

The integration of drone-based photogrammetry and DGPS ensures that topographical data is captured with high precision and spatial accuracy. These tools allow the generation of essential geospatial outputs such as orthophotos, Digital Terrain Models (DTM), Digital Elevation Models (DEM), and dense point clouds. These outputs form the basis for terrain analysis, surface modeling, and infrastructure planning. Using this data, terrain-sensitive decisions regarding road alignment, drainage planning, plot orientation, and land zoning can be made with high confidence.

AutoCAD Civil 3D plays a pivotal role in this workflow by offering a complete platform for civil engineering design. It provides tools for designing alignments, profiles, corridors, surfaces, cross-sections, and parceling. For this project, Civil 3D was used to generate a complete layout plan that includes plot boundaries, a central road, public utility areas, green spaces, and parks—all designed in strict adherence to the DTCP (Directorate of Town and Country Planning) regulations. The layout complies with zoning regulations, setback requirements, and percentage-based land use distribution for residential, recreational, and infrastructural purposes.

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The selected layout area of 4082.451 square meters was part of a larger 32-acre campus surveyed using drone technology. The rectangular area was chosen for its suitable topography and accessibility. The layout includes 11 standardized residential plots, each measuring 10m x 15m (150 m²), a centrally planned road of 95.765 meters in length and 6 meters in width, and designated spaces for parks, greenery, utilities, social infrastructure, and parking. This zoning ensures that the area is both livable and regulation-compliant, making it suitable for implementation in real-world scenarios.

Additionally, this project extends beyond layout planning by including the planning of a standardized residential building applicable to all plots. This Ground structure includes living spaces, bedrooms, kitchen, and sanitation facilities. The same design was replicated across all plots to ensure uniformity and facilitate quantity estimation. The estimation phase covered both the road and building components, giving detailed calculations of earthwork, pavement layers, concrete, brickwork, plastering, flooring, and MEP services. These quantities are essential for cost forecasting and materials procurement in real-world construction projects.

The inclusion of road design using Civil 3D's corridor modeling tools demonstrates a practical understanding of road geometry, vertical profiles, slope design, and earthwork computation. Similarly, the parcel creation tool in Civil 3D was used to create and label the individual plots, utility zones, and green areas—further showcasing the project's completeness from a planning perspective.

Overall, this project highlights the capabilities of modern civil engineering practices in land development. It reflects a multi-disciplinary approach combining surveying, GIS, transportation engineering, building design, and quantity surveying. The adoption of drone and DGPS technologies for data acquisition, combined with the design efficiency of Civil 3D, results in a robust and scalable development model suitable for academic, commercial, and governmental applications.

By working on this project, we students not only gain hands-on experience in using professional tools but also understand how theoretical knowledge is translated into practical planning, design, and execution in the real world. This experience prepares them for industry roles where integrated digital workflows and smart planning are becoming the new norm in infrastructure development

II. OBJECTIVES

- Conduct drone and DGPS survey for high-accuracy topographical data
- Generate DTM, DEM, orthoimage, and point cloud
- Design a residential layout per DTCP rules
- Create plots, roads, parks, and utility areas
- Design one road (95.765 m long) using Civil 3D
- Develop a standardized building plan
- Perform quantity estimation for building and road

Study Area Description

- Location: CJITS, jangaon
- Total Campus Area: 31 acre -21 guntas
- Selected Layout Area: 4082.451 m²
- Dimensions: 95.765 m × 42.6299 m
- The area includes natural undulations, vegetation, and is suited for residential use.

Drone and DGPS Survey and Data Collection

- Pre survey planning
- Equipment setup
- Mission planning
- Ground control points

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- Autonomous flight execution
- Data acquisition

Fig.1- Data collection

Fig.2 - mission planning

Fig 3- Ground control points

Fig .4 Drone

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III. BUILDING ESTIMATION

Batch-4 Building Estimation								
QUANTITY SHEET								
Sr. No.	Item Description	No.	Length (m)	Width/ Breadth (m)	Height/ Depth (m)	AREA	Quantity	Unit
1	Earthwork in excavation in foundation							
	Footing size for excavation (1.3x1.3)	11	1.3	1.3	1.7		31.603	cum
	Depth from GL=(1.3+0.3+0.1=1.7)							
2	Footing PCC	11	1.2	1.2	0.1		1.584	cum
	Thickness=0.1							
	1.2x1.2 size							
3	Footing RCC	11	1	1	0.3		3.3	cum
	Base(1m*1m)							
	Thickness=0.3							
4	Column up to Plinth level RCC	11	0.23	0.3	1.3		0.9867	cum
	from top of rcc footing to bottom of plinth height (1.7-0.3-0.1=1.3)							
5	plinth quantity (Size 0.23x0.23)				0.23	13.808	3.17584	cum
6	pcc for flooring quantity (total built area -plinth area(97.2411-13.808=83.4331				0.1	83.4331	8.34331	cum
7	basement gravel filling total built area – plinth area xthickness(97.2411-13.808x0.6)				0.6	83.4331	50.05986	cum
8	Stone shabad flooring total built area – wall area (97.2411-3m wall and 1m wall area 13.808					83.4331		sqm
9	3m wall quantity							
	3m height wall area (13.003)				3	13.003	39.009	
	wall openings deduction							
	O	3	1.2	2.1	0.23		1.7388	
	MD	1	1.2	2.1	0.23		0.5796	
	D1	1	1	2.1	0.23		0.483	

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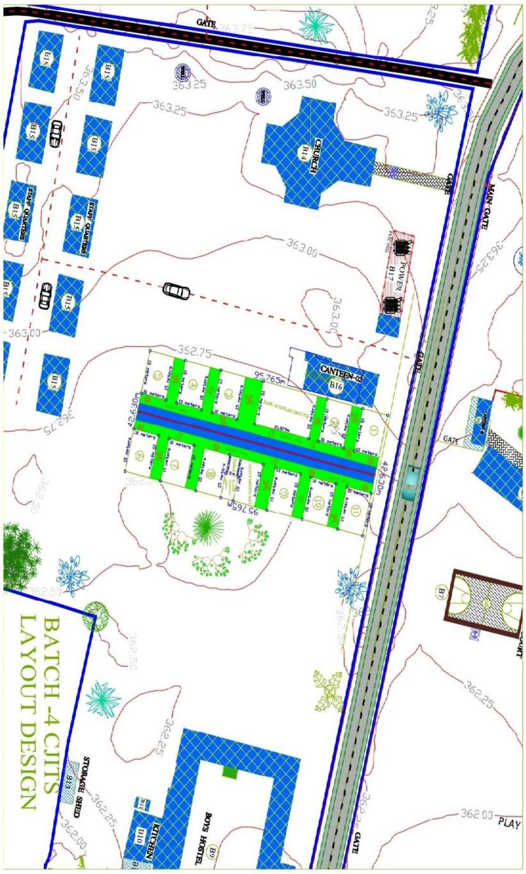
	D2	2	0.75	2.1	0.12		0.378	
	W	2	2	1.2	0.23		1.104	
	W1	3	1.5	1.2	0.23		1.242	
	W2	3	1.2	1	0.23		0.828	
	V	1	0.9	0.6	0.23		0.1242	
	V1	1	0.6	0.6	0.23		0.0828	
	total deduction						6.5604	cum
	total wall quantity after deduction						32.4486	
10	1m wall quantity for verandah	1	2.3	0.23	1		0.529	cum
11	roof beam rcc quantity				0.23	13.287	3.05601	cum
12	slab rcc quantity	1	9.69	12.19	0.15		17.718165	cum
13	parapet wall quantity	1			1	4.979	4.979	cum
14	columns from plinth to roof							
	floor to floor height 3m-roof beam depth =2.77m	11	0.23	0.3	2.77		2.10243	cum



IV. RESULTS

High-Accuracy Topographical Mapping

- Drone photogrammetry and DGPS provided centimeter-level accuracy in mapping.
- Deliverables like orthophotos, DTM, DEM, and 3D point clouds ensured high spatial fidelity, crucial for terrain-sensitive design decisions.
- GCPs and RTK corrections minimized errors, creating reliable base data.

DTCP-Compliant Residential Layout

- The layout strictly adheres to DTCP guidelines with 40.42% land allocated for residential use, 14.07% for roads, and 28% for open and green spaces.
- Space distribution includes:
  - Parks and playgrounds: 8.04%
  - Social infrastructure: 3.17%
  - Greenery: 20%
  - Utilities and safety buffers: 13.5%
- Such planning supports sustainable living, social well-being, and ecological resilience.

Civil 3D-Driven Road and Parcel Design

- 6 m wide, 95.765 m long road designed with vertical alignment, assemblies, and corridor modeling.
- Road designed to follow natural terrain contours, minimizing cut-and-fill volumes (~345.7 m^3 for sub-base).
- Parcel tool used to define 11 plots and communal areas with clear labeling and zoning.

Building Planning and Standardization

- A ground floor residential unit was standardized for all 11 plots.
- Built-up area per house: ~118.13 m^2.
- Space-efficient and regulation-compliant with designated setbacks and ventilation.
- Layout includes living room, bedroom, kitchen, bathroom, toilet, passage, and verandah.

Comprehensive Quantity Estimation

- RCC total: ~30.5 m^3, requiring ~3.18 tons of reinforcement steel.
- Brickwork: ~90.74 m^3 (≈ 45,370 bricks).
- Plastering: ~780 m^2; Stone flooring: ~118 m^2.
- Road components: Estimations across paving, base, and sub-base layers clearly calculated.

Sustainability and Environmental Considerations

- Layout preserves natural undulations and vegetation.
- Terrain-sensitive road alignment limits erosion risk and visual disturbance.
- Green cover exceeds DTCP minimums, enhancing climate resilience.

Design Automation and Time Savings

- Civil 3D automation reduced planning and drafting time significantly.
- Cut-and-fill computations and quantity takeoff reduced manual labor and potential errors.
- 3D modeling enhanced stakeholder communication, aiding faster approvals.

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V. CONCLUSION

This project presents a fully-realized example of modern urban planning through the fusion of geospatial technologies and intelligent civil engineering design. The implementation of drone-based surveying and DGPS data collection enabled unprecedented precision in site modeling, allowing for a terrain-responsive and regulation-compliant design.

Using AutoCAD Civil 3D, the residential layout was planned with a clear focus on sustainability, livability, and functional zoning. It not only meets but exceeds DTCP standards for road width, green space, plot size, and utility provision. Furthermore, the project incorporates a modular building design, facilitating streamlined construction and material planning across all 11 residential plots.

The detailed quantity estimation empowers project stakeholders with accurate cost, material, and labor forecasts, reducing wastage and improving budgeting efficiency. Earthworks and materials for roads and buildings were computed with industry-accepted practices, reinforcing the project's practicality.

From an academic and professional standpoint, this project demonstrates how civil engineers can harness GIS, UAV technologies, and digital design platforms to meet the growing demands of urban expansion in a sustainable, cost-effective, and compliant manner. The students involved gain critical experience in digital surveying, design automation, and regulatory frameworks—preparing them for a rapidly evolving industry landscape.

Ultimately, this GIS-enabled design is not merely a student exercise but a scalable prototype for future residential planning in peri-urban India, aligning with both technological progress and policy initiatives like the HMDA Master Plan 2031 and Smart Cities Mission.

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