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Analyse and Design of Urban Sewer Network Using SewerGEMS Software

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Abstract: The study titled "Analyse and Design of Urban Sewer Network Using SewerGEMS Software" focuses on the need for efficient and sustainable sewerage systems in rapidly developing metropolitan areas like Hyderabad. Due to increasing population and urbanization, the existing sewer networks often face challenges such as overflows, blockages, and inadequate capacity. This research aims to analyze and redesign the sewer network of Gayatri Nagar under the Greater Hyderabad Municipal Corporation (GHMC) using advanced hydraulic modelling through SewerGEMS software. The methodology involves systematic data collection, including layout and topographical mapping through Google Earth Pro and QGIS, and estimation of sewage generation based on population and water consumption data. The collected data are integrated into SewerGEMS to simulate the existing network and assess hydraulic parameters such as flow velocity, hydraulic grade line (HGL), and manhole surcharge levels. Based on the analysis, deficiencies such as undersized pipes and low slopes were identified. A redesigned network was then proposed by optimizing pipe diameters, slopes, and alignments to achieve self-cleansing velocity and efficient wastewater conveyance. The results obtained from SewerGEMS were compared with conventional manual design methods using standard hydraulic equations. The comparison revealed that software-based modelling provides greater accuracy, faster analysis, and enhanced visualization of flow characteristics. Additionally, a Sewage Treatment Plant (STP) was designed to ensure proper wastewater treatment and disposal. Overall, the study concludes that SewerGEMS is a powerful tool for urban sewer system design, promoting sustainability, efficiency, and improved urban sanitation.

***Keywords*: SewerGEMS, Sewer Network Design, Hydraulic Modelling, Sewerage System, Manhole Surcharge, Self-Cleansing Velocity, QGIS, Google Earth Pro, Population Data, Sewage Generation, Pipe Optimization, Conventional Design Method, Sustainable Urban Sanitation, Hydraulic Analysis, Sewer Optimization, Wastewater Disposal, GIS Integration, Hydraulic Simulation, Urban Infrastructure Planning.**

I. INTRODUCTION

Urbanization has significantly increased the pressure on cities to develop efficient and sustainable sewerage systems that safeguard public health and preserve environmental quality. As urban populations expand, the management of wastewater and stormwater becomes increasingly complex, demanding advanced planning and design solutions. Traditionally, sewer system design depended on manual hydraulic calculations using empirical formulas and standard charts to determine parameters such as discharge, velocity, and slope. While these conventional methods were reliable, they were also time-consuming, labour-intensive, and susceptible to human error, especially when dealing with large and complex urban networks.

To address these limitations, modern technologies such as SewerGEMS and QGIS have emerged as powerful tools for data-driven and efficient sewer network design. SewerGEMS, a hydraulic modelling software, enables engineers to simulate flow parameters including velocity, slope, hydraulic grade line (HGL), and manhole surcharge levels. This allows for the identification of hydraulic bottlenecks, optimization of pipe sizes, and improved alignment planning. QGIS, on the other hand, provides spatial mapping and geo referencing capabilities that help visualize existing and proposed networks within their real-world geographical context.

The integration of hydraulic modelling and spatial analysis in this study facilitates a comprehensive assessment of the existing sewer network and aids in developing a more efficient proposed design. By comparing the SewerGEMS-based design with conventional manual approaches, the study demonstrates significant improvements in accuracy, design speed, visualization, and overall network performance, thereby promoting sustainable urban infrastructure development.

A. Objectives

The objectives of the present work are as follows:

1) To analyse the sewer network of Gayatri Nagar, Hyderabad, using SewerGEMS software.
2) To utilize SewerGEMS software for designing an efficient sewer network.

II. STUDY AREA

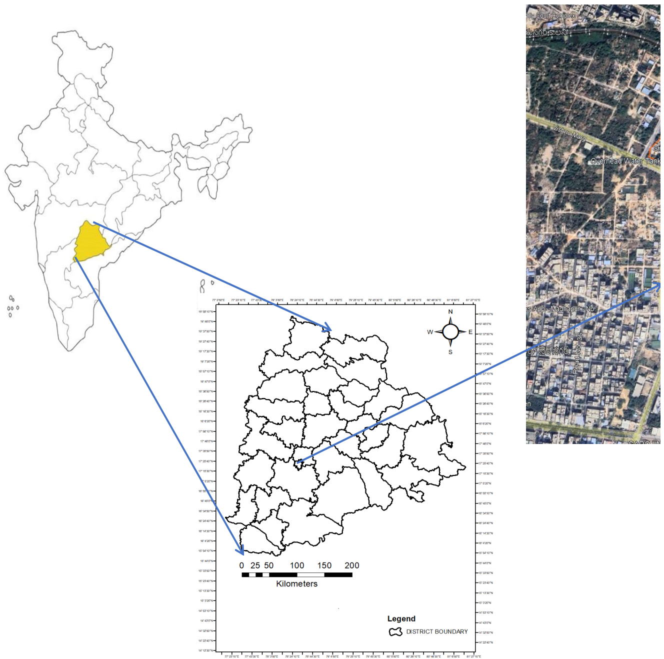

Fig-1 Location of the study area

The selected study area, Gayatri Nagar, is a well-known urban neighbourhood located within Allapur, Borabanda, in the metropolitan region of Hyderabad, Telangana. It has been chosen for its urban characteristics and relevance to developmental, geographical, and infrastructural studies. Geographically, the area lies between 17°40’36’’ N to 17°45’30’’ N latitude and 78°39’13’’ E to 78°42’41’’ E longitude, covering a total extent of 56.66 hectares. The coordinates define clear boundaries, allowing precise mapping and analysis using geospatial tools. The region falls under the WGS 84/UTM Zone 44 N projection system, ensuring spatial data accuracy and compatibility with regional and global datasets.

Gayatri Nagar represents a typical urban residential locality characterized by rapid population growth, expanding infrastructure, and increasing demand for civic amenities. Its proximity to key urban centres enhances its significance in terms of connectivity and accessibility. The area also faces challenges common in urban environments, such as unplanned development, traffic congestion, and waste management issues. The defined geographical limits make it ideal for spatial analysis, urban planning, and hydraulic modelling using modern tools like QGIS and SewerGEMS. Overall, Gayatri Nagar serves as an effective case study for evaluating sustainable urban infrastructure design and management in growing Indian cities.

III. METHODOLOGY

The methodology adopted for the study titled “Analyse and Design of Urban Sewer Network Using SewerGEMS Software” follows a systematic approach integrating geospatial analysis, hydraulic modelling, and comparative evaluation. The process begins with Google Earth Pro, used to delineate the study area and generate the contour map, providing essential topographic details. These spatial datasets are imported into QGIS for further processing, mapping, and layout preparation. The population data obtained from HMWS&SB (Hyderabad Metropolitan Water Supply and Sewerage Board) is incorporated to estimate sewage generation based on per capita water consumption.

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The processed data is then integrated into SewerGEMS software, which enables hydraulic modelling of the existing sewer network. Through this, parameters such as flow velocity, slope, and hydraulic grade line (HGL) are analysed to identify existing problem locations, including undersized or overloaded pipes. Based on these findings, an optimized sewer network design is developed to ensure self-cleansing conditions and adequate capacity.

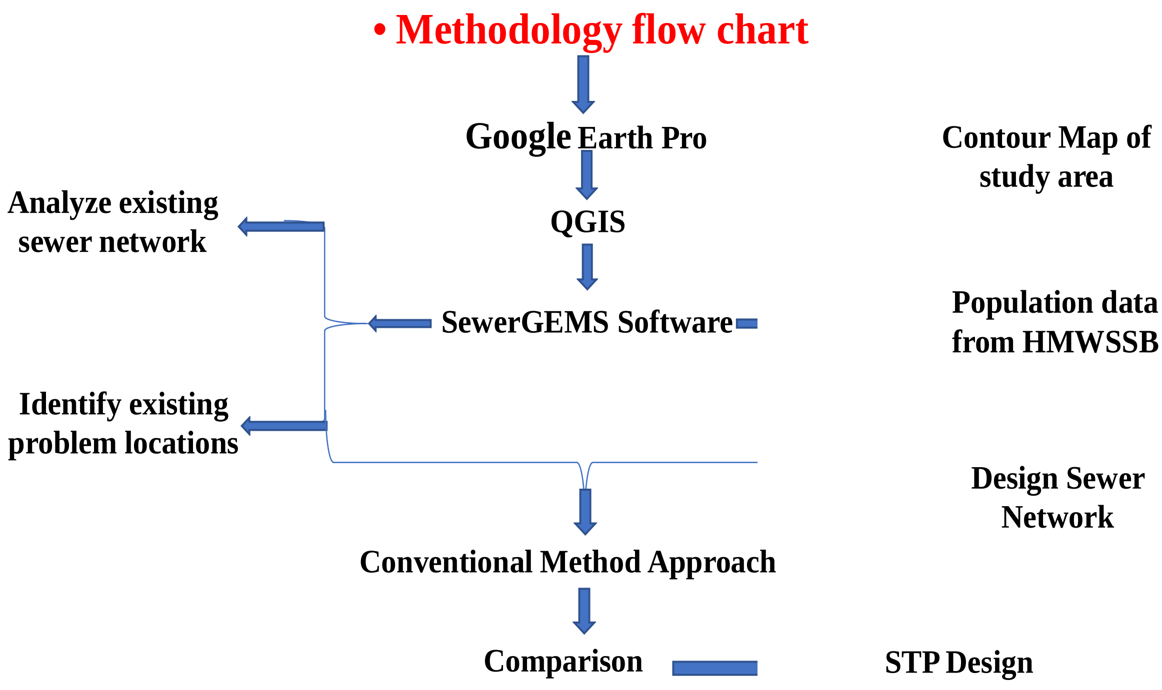

Fig-2 Methodology flow chart

IV. RESULTS AND DISCUSSIONS

A. Manhole Description

The manhole dataset represents the hydraulic and geometric characteristics of nodal points in the sewer network. Each manhole facilitates inspection, maintenance, and flow distribution. Elevation parameters, including rim and invert levels (ranging from 554.6 m to 569.75 m), define manhole depth, which varies from 1.2 m to 7.9 m depending on terrain and hydraulic gradient. Hydraulic parameters such as inflow, outflow, and sanitary load ensure balanced discharge, with high-flow nodes like MH-15 handling up to 5.6 MLD. The hydraulic gradient line (HGL) shows smooth energy loss along the network, maintaining gravity flow and preventing surcharging. Flow gradually increases downstream, confirming efficient collection and self-cleansing velocities. Functionally, manholes serve as access, junction, and ventilation points essential for maintenance and pressure regulation. Overall, the dataset indicates a well-graded, hydraulically balanced network designed according to CPHEEO standards, ensuring effective wastewater conveyance and sustainable system performance.

Table no: 1 Flex table – Manhole table by sewergems method

Id	Label	Elevation ground(m)	Flow total IN (MLD)	Flow total OUT (MLD)	Hydraulic gradient line (out)(M)	Hydraulic gradient line (in)(M)	Depth structure (m)	Elevation (invert out)(m)	Flow (system sanitary loads)(l/day)
56	MH-15	556	5.623	5.638	554.83	554.83	1.4	554.6	5,588,871.35
47	MH-9	557.12	3.008	3.024	555.04	555.04	2.25	554.87	2,998,254.07
390	MH-162	558.52	2.577	2.599	555.4	555.4	3.27	555.24	2,575,936.27
368	MH-88-6	559.02	1.835	1.857	557.12	557.12	2.04	556.98	1,847,388.36
367	MH-88-5	560	1.798	1.835	557.36	557.36	2.78	557.22	1,825,417.58
370	MH-88-8	557.24	1.894	1.913	556.14	556.14	1.24	556.01	1,902,461.48
369	MH-88-7	558	1.857	1.894	556.4	556.4	1.74	556.26	1,883,125.66
189	MH-74	560.25	1.969	2.014	557.71	557.71	2.68	557.57	2,000,045.15

B. Conduit Description

The conduit dataset provides detailed hydraulic and geometric information about the underground sewer network, linking manholes and outfall points. All conduits are circular, with diameters ranging from 197.4 mm to 395.2 mm, predominantly 200 mm, ensuring efficient hydraulic performance and structural stability. Pipe lengths vary between 9 m and 392 m, with slopes from 0.01 m/m to 0.45 m/m, maintaining gravity flow and self-cleansing velocity. The Manning's roughness coefficient (n = 0.01) and velocity range (0.2–1.0 m/s) confirm smooth, energy-efficient flow conditions. Constructed from Double Wall Corrugated Polyethylene (DWC-PE), the conduits offer corrosion resistance, durability, and ease of installation. Elevation data (556–569 m) illustrate proper topographic alignment for continuous flow without backpressure. Flow rates from 0.02 to 5.64 MLD demonstrate a well-graded hierarchy from branch to trunk lines. Overall, the dataset reflects an optimized, sustainable, and hydraulically balanced design suitable for modern urban sewer systems

Table no:2 Flex table – Conduit table by sewergems method

ID	Label	Start node	Stop node	Length scaled(M)	Slop (%)	Section type	Diameter(mm)	Elevation ground (start)(m)	Elevation ground (stop)(m)	diameter	Catalogue class	Mannings	Velocity(m/s)	Flow (MLD)
376	Sewer line-1(2)-6	MH-88-5	MH-88-6	59	0.41	Circle	197.4	560	559.02	200	DWC-PE	0.01	0.96	1.835
375	Sewer line-1(2)-5	MH-88-4	MH-88-5	59	0.41	Circle	197.4	559.08	560	200	DWC-PE	0.01	0.95	1.799
388	Sewer line -1(2)-9(2)(1)	MH-9	MH-15	38.8	0.304	Circle	248.5	557.12	556	200	DWC-PE	0.01	0.97	3.024
373	Sewer line-1(2)-3	MH-88-2	MH-88-3	59	0.451	Circle	197.4	559.64	558.91	200	DWC-PE	0.01	0.98	1.721
371	Sewer line-1(2)-1	MH-88	MH-88-1	59.2	0.451	Circle	197.4	560.32	559.45	200	DWC-PE	0.01	0.98	1.654
372	Sewer line-1(2)-2	MH-88-1	MH-88-2	59	0.41	Circle	197.4	559.45	559.64	200	DWC-PE	0.01	0.94	1.69
386	Sewer line-4(2)(1)(1)	MH-71	MH-8	123.1	0.41	Circle	197.4	560.76	562.1	200	DWC-PE	0.01	0.94	1.683
391	Sewer line-4(1)(1)	MH-15	MH-162	161.4	0.304	Circle	248.5	556	558.52	200	DWC-PE	0.01	0.94	2.599

C. Out Fall Description

The outfall dataset defines the terminal discharge point (O-1) of the sewer network, where all upstream flows converge before release. It has a ground elevation of 556.88 m and an invert elevation of 554.58 m, giving a structural depth of about 2.3 m that maintains sufficient hydraulic head for gravity flow. The boundary condition is a "Free Outfall," allowing wastewater to discharge under atmospheric pressure without backflow. The hydraulic grade line (HGL) at 554.76 m confirms open-channel flow conditions. Outfall O-1 handles approximately 5.64 MLD, ensuring efficient final discharge and compliance with environmental and design standards.

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Table no: 03 Flex table – Out fall table by sewergems method

id	label	elevation ground (m)	set rim to ground elevation	elevation invert(m)	Boundary condition type	hydraulic grade (m)	outfall
223	O-1	556.88	TRUE	554.58	Free Outfall	554.76	5.63887

D. Engineering Profile

The Engineering Profile of a sewer line is a crucial graphical output generated after the COMPUTE step in hydraulic modelling software such as SewerGEMS. It visually represents the geometric and hydraulic behaviour of a gravity-flow sewer system along a selected stretch of pipes and manholes. The profile plots Elevation on the vertical axis and Station Distance on the horizontal axis, illustrating how the sewer line follows ground topography. The Green Line indicates the Ground Surface Elevation, ensuring sufficient cover depth above the pipeline for protection and stability. The Black or Dark Blue Line denotes the Pipe Invert Elevation, representing the lowest internal surface of the pipe that determines the flow slope and direction. The Light Blue Line, or Hydraulic Grade Line (HGL), shows the simulated water surface elevation within the pipe. Maintaining the HGL below manhole rims and ground level is essential to prevent surcharge and surface flooding. Each Manhole (MH) is labelled with its ground and invert elevations, showing connectivity between conduits. The slope of the invert line is carefully designed to achieve self-cleansing velocity, minimizing sediment deposition. By analysing this profile, engineers can identify hydraulic inefficiencies or design anomalies and make necessary adjustments to optimize system performance and reliability.

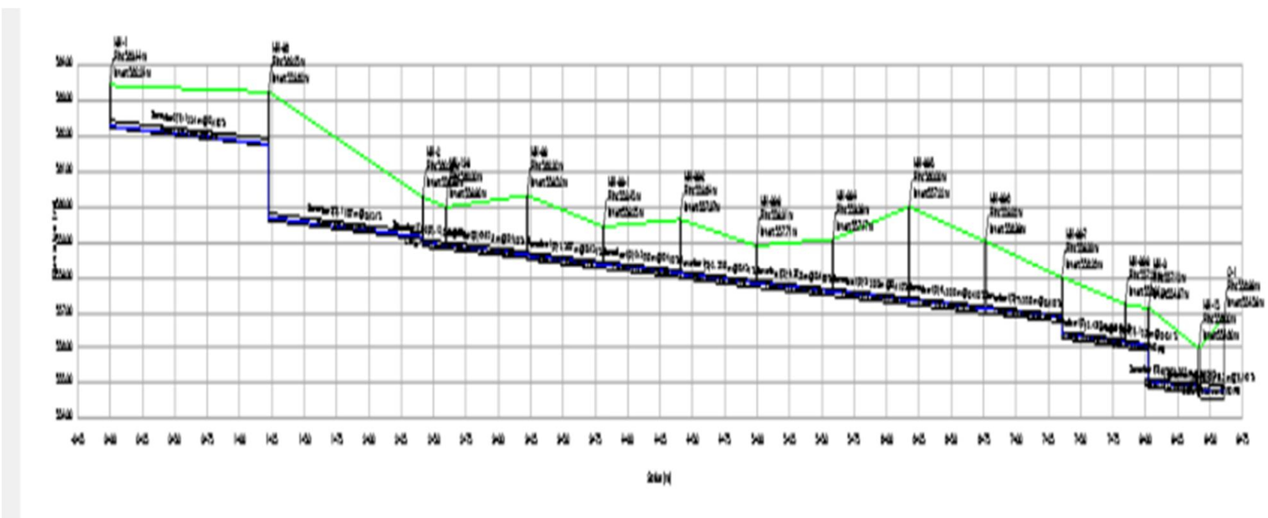

Fig-3 Engineering Profile by sewergems method

E. Profile format

The graph illustrates the relationship between Elevation (m) and Station (m), depicting the longitudinal profile of a sewer line. The Green Line represents the Ground Surface Elevation, ranging from approximately 556.5 m to 563.5 m over a distance of 0–850 m, showing the natural topography and required pipe burial depth. The Dark Blue Line indicates the Pipe Invert Elevation, starting at about 562.5 m and dropping to 554.5 m, defining the slope essential for gravity-driven flow. The Light Blue/Red Line represents the Hydraulic Grade Line (HGL), showing the internal water surface level, with values around 562.7 m at Station 0 m and 554.7 m at Station 800 m. The consistent gap between the HGL and ground surface confirms that the system operates effectively under gravity without surcharging or overflow risk. Notable invert elevation drops near Station 150 m and Station 800 m suggest manholes or drop structures for energy dissipation and flow transition. The slope of the invert ensures self-cleansing velocities, preventing sediment buildup. Overall, the graph demonstrates a well-designed, hydraulically balanced sewer profile capable of efficient wastewater conveyance and long-term operational reliability.

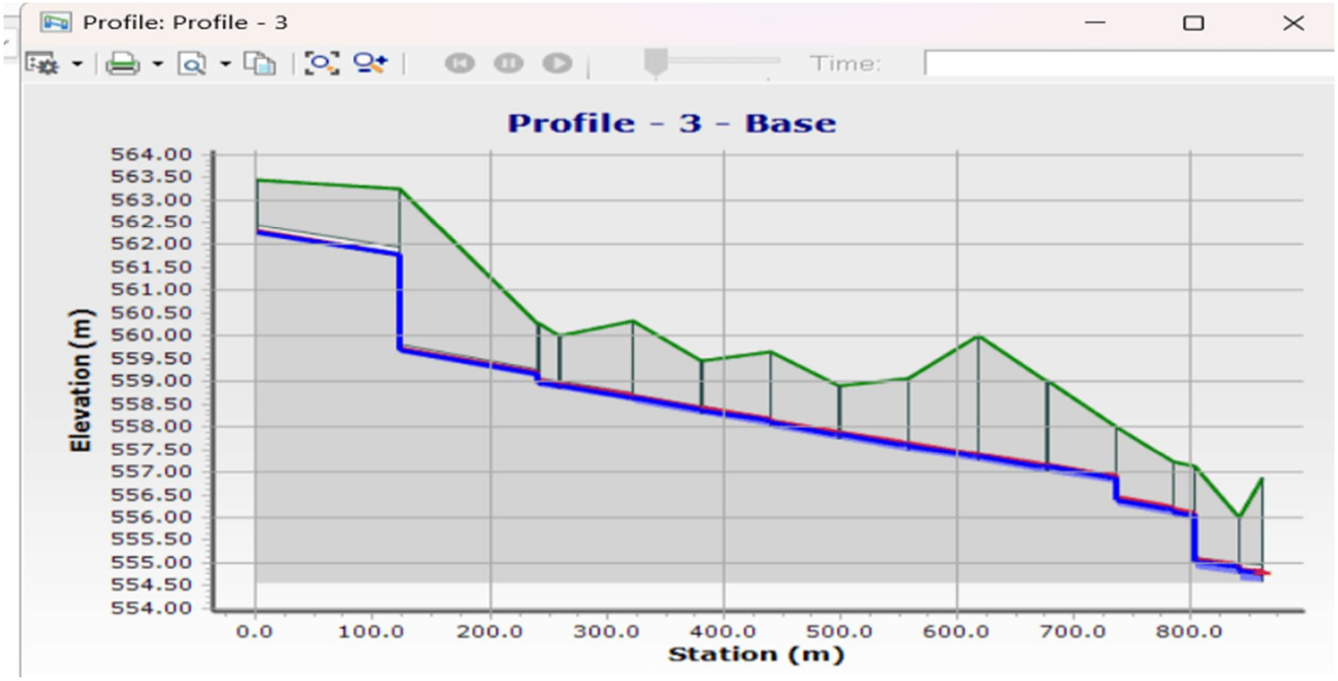

Fig-4 Profile format by sewrgems method

V. CONCLUSIONS

The study concludes that the integration of SewerGEMS and GIS-based tools provides a highly efficient, reliable, and sustainable approach for modern sewer network design compared to traditional manual methods. SewerGEMS automates complex hydraulic computations, reducing human error and design time while adhering to CPHEEO standards. It ensures accurate slope, velocity, and diameter optimization, achieving both functional and cost efficiency. The integration of Google Earth Pro and QGIS with SewerGEMS enhanced topographical accuracy, load allocation, and elevation modelling, resulting in realistic simulations and improved design precision. Hydraulic validation through Flex Tables and Engineering Profiles confirmed safe HGL levels, effective gravity flow, and overall structural stability.

From a hydraulic standpoint, the methodology successfully optimized pipe diameters, slopes, and flow conditions, ensuring adequate capacity under both normal and peak scenarios. The incorporation of extraneous flows and extreme flow simulations strengthened the model's resilience and adaptability to future population growth and climate change impacts. Material standardization and error validation ensured constructability and model consistency, supporting practical field implementation.

Beyond technical performance, the study emphasizes broader benefits in public health, sustainability, and governance. The optimized design reduces blockages, flooding, and untreated discharges, improving hygiene and environmental quality. Economically, the methodology minimizes material usage and construction costs, supporting sustainable resource management. Its scalability and compatibility with smart technologies (SCADA/IoT) make it a forward-looking tool for smart city initiatives.

Overall, the study establishes SewerGEMS as a foundational decision-support and planning tool, bridging academic research and real-world engineering applications. It promotes data-driven, sustainable, and resilient urban sanitation infrastructure aligned with India's Smart Cities Mission, AMRUT, and UN SDG 6 (Clean Water and Sanitation) objectives.

VI. ACKNOWLEDGEMENT

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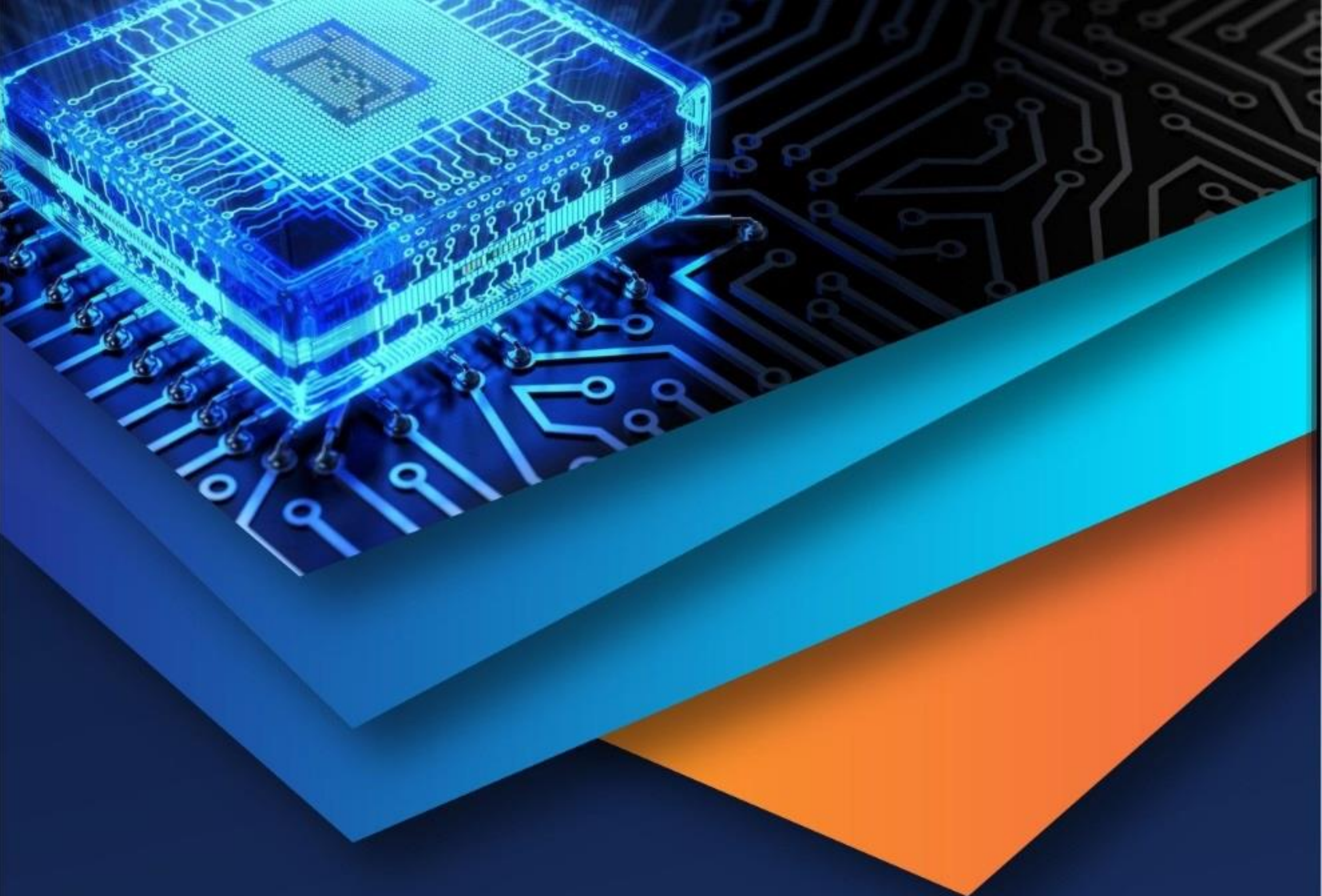

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