International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 10, October - 2025

Design of Sewerage Network for Tumbigere Village using Openflows SewerGEMS and QGIS

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***Abstract* - This study presents the design of a sewer network for Tumbigere village using QGIS and SewerGEMS software. QGIS was used to generate spatial and elevation data, while SewerGEMS enabled hydraulic modelling and system optimization. The design integrates both gravity conduits and pressure lines with pumping provisions to overcome terrain limitations and ensure continuous flow. This approach provides a reliable, cost-effective, and sustainable sewage conveyance system that improves sanitation and safeguards public health in the village. The results of this study can serve as a reference for developing sewerage infrastructure in similar rural settlements. The methodology also demonstrates the effective use of GIS and hydraulic modelling tools for planning and designing future wastewater management systems.**

***Keywords*: SewerGems, Conduits, Manholes, Sewer Network, Outfall**

I INTRODUCTION

The efficient design of sewer networks is essential for ensuring sustainable urban growth and safeguarding public health. This study focuses on the design of a sewer system using SewerGEMS software for Tumbigere village located in Davangere district, Karnataka, India. Traditional sewer design methods are often time-consuming and tedious, requiring extensive manual calculations. Any change in design parameters necessitates a complete re-analysis, making the process inefficient and prone to human error.

In many urban regions, sewage and stormwater are conveyed either through a combined sewer system or a separate system where sanitary and storm drains function independently. Despite regular maintenance through access points like manholes, these systems may fail during periods of intense rainfall, leading to combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs). Such failures are often aggravated by factors like poor system planning, lack of maintenance, and outdated infrastructure, which result in the discharge of untreated wastewater into nearby water bodies, posing threats to both the environment and public health.

Designing a sewer system is a complex process that requires consideration of multiple parameters, including pipe slope, flow velocity, invert levels, excavation depth, and cost optimization. Achieving a balance between hydraulic efficiency, maintenance feasibility, and economic viability is crucial for an effective network design.

SewerGEMS offers a significant advantage by integrating hydraulic modeling tools with AutoCAD and Geographic Information System (GIS) platforms. It enables engineers to analyze, optimize, and modify sewer systems efficiently, providing alternative solutions for improved performance. Its dynamic simulation capabilities make it a comprehensive and user-friendly tool for the design and analysis of both sanitary and combined sewer systems, ensuring a reliable and sustainable approach to wastewater management.

OBJECTIVE OF THE STUDY

1. To gather and examine essential data, including demographics, landscape features, land utilization, and water usage, that is essential for planning a sewer network.
2. To develop a practical and efficient sewerage system for the village with the help of SewerGEMS software, ensuring compliance with environmental and public health regulations.
3. To implement established hydraulic design principles, such as Manning’s equation and self-cleansing velocity, within the software to enable precise system modeling.
4. To assess the sewer design produced by the software, focusing on aspects like pipe dimensions, gradients, flow speeds, and distribution patterns.
5. To validate the design methodology by comparing it with conventional manual approaches, emphasizing the benefits of utilizing SewerGEMS for planning.

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II LITERATURE REVIEW

A. General

The design and management of sewer systems are crucial for public health and sustainable urban development. Traditional manual design methods, though informative, are time-consuming and prone to human error. With advancing technology, SewerGEMS has emerged as an efficient tool for sewer network design and analysis. It enables precise hydraulic modeling and integrates seamlessly with GIS for spatial analysis. Engineers can simulate real-world conditions and optimize pipe sizes and layouts effectively. Studies have shown that SewerGEMS improves design accuracy and reduces the time required for analysis. It allows better evaluation of system performance under varying loads. Compared to manual methods, SewerGEMS offers higher flexibility, reliability, and cost efficiency. Overall, it enhances the planning and management of sustainable sewer infrastructure.

B. Literature Studies

Murugesh et al. (2015) concluded that Bentley SewerGEMS enables faster and more efficient project completion. It is recognized as a dynamic, multi-platform tool (GIS, CAD, and Stand-Alone) for modeling clean and combined sewer systems. The software supports hydraulic analysis, slope calculation, and the generation of detailed design reports and cross-sections.

Gupta et al. (2017) stated that sanitary sewer frameworks are vital infrastructure for managing water pollution but are complex due to intricate hydraulics. Traditional design methods based on Hazen-Williams and Manning's equations are limited in applicability, emphasizing the need for optimization and accuracy in modern sewer design.

Patel and Ankita Parmar (2019) highlighted that sewer systems are crucial for environmental sustainability and public health protection. Their study utilized SewerGEMS V8i, a fully dynamic, multi-platform modeling solution, for the design and analysis of sanitary and combined sewer systems.

Padgaonkar et al. (2023) designed a sewerage framework compatible with existing infrastructure to support rapid development. Using the Sewer Diamonds program, they analyzed the sewer network and generated outputs like pipe alignment, gradients, diameters, flow velocities, and cover levels for effective system planning.

Gajre and Regulwar (2024) emphasized that efficient sewer system design ensures urban sustainability and public health. Their study, based on CPHEEO guidelines, focused on maintaining parameters like velocity, slope, and tractive force within limits. Using SewerGEMS, they optimized pipe sizes and materials, recommending integration of wastewater recycling and long-term performance evaluation in future research.

Dawood and Mawlood (2024) focused on storm sewer design under rapid urbanization using SewerGEMS and QGIS 3D mapping. Their results provided detailed hydraulic parameters including flow velocity, pipe diameter, gradients, hydraulic grade line, and excavation depth, demonstrating the tool's capability in optimizing stormwater management systems.

C. Research Gap and Relevance

Although there are not many specific studies focusing on Tumbigere Village, approaches and insights from comparable rural infrastructure projects can be effectively utilized to plan the village's sewage system. Situated in the Davangere district, Tumbigere shares similar topographical and demographic features with other rural areas where SewerGEMS has been successfully implemented. This indicates that using the software to create an efficient and sustainable sewer network that meets the village's terrain, population distribution, and future growth requirements is a suitable choice.

III METHODOLOGY

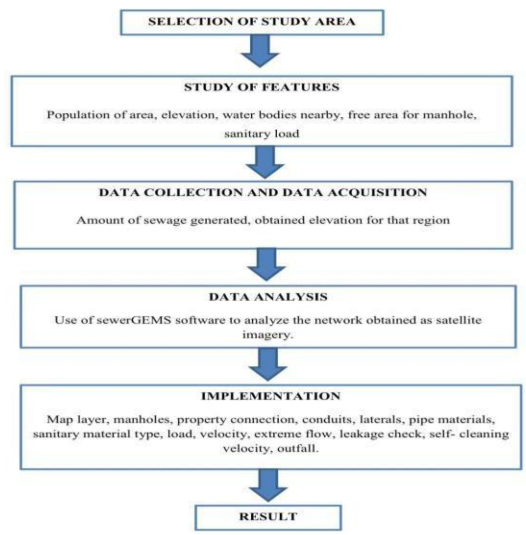

Fig.1. Methodology flowchart showing the modelling of a sewerage network

A. Study Area – Tumigere Village

Tumbigere is a rural village in Davangere taluk, Karnataka, with a population of 817 as per the 2011 Census. It lies in a tropical monsoon region receiving 870–1,120 mm of annual rainfall. The area consists mainly of residential zones and small agricultural lands with basic sanitation infrastructure. With population growth, a planned sewer system is essential to improve hygiene, wastewater management, and sustainable rural development.

Fig. 2. Study area selected

B. Data Collection

For the design of the sewerage network, essential data were obtained from Census of India (2011), IS 1172:1993 – Code of Basic Requirements for Water Supply, Drainage and Sanitation, and the CPHEEO Manual. The major parameters include population, water demand, and sewage generation.

- Base Year Population (2011): 817 (Census of India, 2011)
- Water Supply Rate: 135 LPCD (IS 1172:1993)
- Sewage Factor: 0.8 (80% of water supplied becomes sewage)
- Population Projection Method: Arithmetic Increase Method, with an average increase of 67 persons/year based on 2001–2011 growth.

The sewage flow (Q) is estimated using the formula: $Q = (P \times 135 \times 0.8) / 1{,}000{,}000$ (in MLD)

TABLE I. POPULATION PROJECTION AND SEWAGE FLOW

Year	Population	Sewage Generation (MLD)	Remarks
2011	817	0.08824	Base year
2025	911	0.09863	Intermediate calculation
2055	1112	0.11995	Design year (30 years)

C. Software Tools Used

a. SewerGEMS

SewerGEMS was utilized for the hydraulic modeling and design of the sewerage network. The software facilitated pipe sizing, slope determination, flow analysis, and network optimization. Various scenario management tools were employed to evaluate system performance under different population growth and flow conditions.

b. QGIS

QGIS was applied for spatial data processing, including the preparation of base maps, terrain evaluation, and slope analysis. The software was also used for catchment delineation and manhole location planning, which were later integrated with SewerGEMS for hydraulic analysis.

c. Hydraulic Simulation (SewerGEMS)

The projected sewage loads were input into SewerGEMS to conduct a hydraulic simulation of the network. The software evaluated the hydraulic performance of conduits and manholes under varying flow conditions.

- Minimum Pipe Diameter: 150 mm, in compliance with CPHEEO guidelines.
- Hydraulic Parameters: Manning's roughness coefficient *(n = 0.013)*; flow velocity maintained between 0.6–3.0 m/s to ensure self-cleansing and prevent scouring.
- Design Flow: A peak factor of 2.5 was applied to the average flow to determine maximum discharge capacity.
- Manholes: Spaced 30–50 m apart, with depths adjusted according to terrain variations.

The simulation results confirmed that the designed network satisfies hydraulic efficiency standards and provides safe and reliable sewage conveyance for both current and future population demands.

IV IMPLEMENTATION

A. QGIS: The first phase of this project will utilize QGIS (Quantum Geographic Information System), which is a free and open-source geographic information system used for visualizing, analyzing, and mapping spatial data. This step is essential for understanding the geographical characteristics, terrain, and current infrastructure within the project site.

QGIS IMPLEMENTATION PROCESS:

Fig.3. Step-by-step GIS mapping workflow in QGIS

B. SewerGEMS: It enables efficient sewer network design by combining advanced hydraulic modeling with GIS data from QGIS. It allows accurate flow simulation, capacity assessment, and identification of bottlenecks, supporting the development of cost-effective, sustainable, and hydraulically efficient wastewater systems.

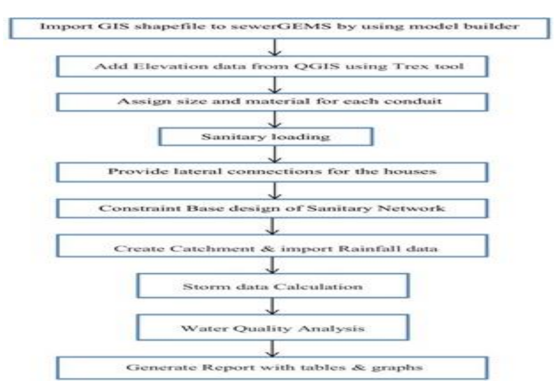

Fig. 4. Workflow of sewerage network

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 10, October - 2025

V RESULTS

A. Conduits

Flow velocities range from 0.71 to 2.36 m/s, within the recommended 0.6–3.0 m/s for self-cleaning. Pipe diameters vary between 250 and 650 mm, meeting design standards. All conduits are RCC (n = 0.013), ensuring durability. Downstream mains carry higher flows, while upstream branches handle smaller flows with adequate slopes. No conduits exceed capacity or risk sedimentation under the current design.

FlexTable: Conduit Table
Current Time: 0.25 hours

ID	Label	Start Node	Stop Node	Catalog Class	Size	Conduit Type	Length (Scaled) (m)	Manning's n	Velocity (m/s)	Flow (m³/s)
64	M-12	M-3	M-2	Circle - Concrete	250 mm	Catalog Conduit	51.7	0.013	0.71	0.0350
63	M-11	M-2	M-17	Circle - Concrete	375mm	Catalog Conduit	37.9	0.013	0.72	0.0690
69	M-17	M-9	M-8	Circle - Concrete	250 mm	Catalog Conduit	90.6	0.013	0.84	0.0410
70	M-18	M-8	M-7	Circle - Concrete	350mm	Catalog Conduit	108.5	0.013	0.84	0.0810
57	M-5	M-13	M-1	Circle - Concrete	250 mm	Catalog Conduit	80.8	0.013	0.96	0.0470
73	M-21	M-12	M-11	Circle - Concrete	400mm	Catalog Conduit	111.1	0.013	0.98	0.0940
74	M-22	M-14	M-12	Circle - Concrete	250 mm	Catalog Conduit	84.6	0.013	0.98	0.0480
312	M-10(1)	H-1	M-16	Circle - Concrete	375mm	Catalog Conduit	13.3	0.013	1.09	0.1199
313	M-10(2)	M-17	H-1	Circle - Concrete	375mm	Catalog Conduit	11.9	0.013	1.09	0.1200
55	M-3	J-1	M-11	Circle - Concrete	375mm	Catalog Conduit	49.4	0.013	1.12	0.1240
56	M-4	M-1	J-1	Circle - Concrete	300 mm	Catalog Conduit	81.5	0.013	1.13	0.0800
61	M-9	M-16	M-15	Circle - Concrete	375mm	Catalog Conduit	49.2	0.013	1.54	0.1700
71	M-19	M-10	M-7	Circle - Concrete	550mm	Catalog Conduit	100.8	0.013	1.57	0.3720
68	M-16	M-15	M-5	Circle - Concrete	400mm	Catalog Conduit	64.3	0.013	1.74	0.2190
67	M-15	M-5	M-4	Circle - Concrete	400mm	Catalog Conduit	49.3	0.013	2.04	0.2560
72	M-20	M-6	M-10	Circle - Concrete	450mm	Catalog Conduit	63.1	0.013	2.08	0.3300
54	M-2	M-11	M-7	Circle - Concrete	400mm	Catalog Conduit	27.8	0.013	2.09	0.2630
66	M-14	M-4	M-6	Circle - Concrete	400mm	Catalog Conduit	69.0	0.013	2.32	0.2920
53	M-1	M-7	O-1	Circle - Concrete	650mm	Catalog Conduit	140.1	0.013	2.36	0.7551

Fig. 5. SewerGEMS model showing layout of conduits

B. Manholes

Manhole depths range from 21.58 to 98.79 m, with flow rates of 0.035–0.755 m³/s, reflecting upstream to downstream accumulation. Hydraulic Grade Line levels remain below rim elevations, indicating no surcharge risk. Slope differences between inlets and outlets ensure self-cleansing velocities, with deepest manholes near downstream mains and shallower ones at upstream branches.

FlexTable: Manhole Table (Current Time: 0.250 hours) (BIET SEWERGEMS.stsw)

	ID	Label	Elevation (Ground) (m)	Elevation (Rim) (m)	Depth (Average) (m)	Flow (Total In) (m³/s)	Flow (Total Out) (m³/s)	Depth (Out) (m)	Hydraulic Grade Line (Out) (m)	Hydraulic Grade Line (In) (m)
35: M-3	35	M-3	545.00	545.00	98.79	0.0350	0.0350	7.02	7.02	7.02
41: M-9	41	M-9	549.00	549.00	33.19	0.0410	0.0410	2.69	2.69	2.69
47: M-13	47	M-13	548.00	548.00	48.17	0.0470	0.0470	3.68	3.68	3.68
48: M-14	48	M-14	548.00	548.00	43.67	0.0480	0.0480	3.38	3.38	3.38
34: M-2	34	M-2	545.00	545.00	96.07	0.0690	0.0690	6.84	6.84	6.84
33: M-1	33	M-1	550.00	550.00	40.52	0.0800	0.0800	3.17	3.17	3.17
40: M-8	40	M-8	547.00	547.00	26.66	0.0810	0.0810	2.26	2.26	2.26
46: M-12	46	M-12	548.00	548.00	35.31	0.0940	0.0940	2.83	2.83	2.83
51: M-17	51	M-17	544.00	544.00	94.78	0.1200	0.1200	6.75	6.75	6.75
50: M-16	50	M-16	547.00	547.00	93.00	0.1700	0.1700	6.63	6.63	6.63
49: M-15	49	M-15	549.00	549.00	85.98	0.2190	0.2190	6.17	6.17	6.17
37: M-5	37	M-5	547.00	547.00	75.20	0.2560	0.2560	5.46	5.46	5.46
45: M-11	45	M-11	550.00	550.00	28.31	0.2630	0.2630	2.37	2.37	2.37
36: M-4	36	M-4	546.00	546.00	63.91	0.2920	0.2920	4.72	4.72	4.72
38: M-6	38	M-6	546.00	546.00	43.33	0.3300	0.3300	3.36	3.36	3.36
42: M-10	42	M-10	547.00	547.00	30.50	0.3720	0.3720	2.51	2.51	2.51
39: M-7	39	M-7	548.00	548.00	21.58	0.7551	0.7551	1.92	1.92	1.92

Fig. 6. Manhole hydraulic performance data from SewerGEMS

C. Summary Scenario

i. Routing Method: Dynamic Wave analysis using SWMM, allowing for surcharge and ponding.

ii. Pressure Pipe Friction: Utilization of the Hazen–Williams equation.

iii. Time Setup: Variable time intervals that vary from a minimum of 0.5 seconds, up to 8 test runs.

iv. Hydrology Method: SCS Unit Hydrograph combined with SCS Curve Number to account for losses.

v. Water Quality: Water quality considerations were not included in this analysis.

vi. Additional: H_2S assessment and Rational Method frequency factors were excluded.

Scenario Summary Report
Scenario: Base

Scenario Summary

ID	1
Label	Base
Notes	
Active Topology	Base Active Topology
User Data Extensions	Base User Data Extensions
Physical	Base Physical
Boundary Condition	Base Boundary Condition
Initial Settings	Base Initial Settings
Hydrology	Base Hydrology
Output	Base Output
Infiltration and Inflow	Base Infiltration and Inflow
Rainfall Runoff	Base Rainfall Runoff
Water Quality	Base Water Quality
Sanitary Loading	Base Sanitary Loading
Headloss	Base Headloss
Operational	Base Operational
Design	Base Design
System Flows	Base System Flows
SCADA	Base SCADA
Energy Cost	Base Energy Cost
Surface Definition	Base Surface Definition
Solver Calculation Options	Base Calculation Options

Hydraulic Calculation Events

Use	Start Date	Start Time	End Date	End Time

Explicit Results Control

Catchments Results Type	All Results	Links Results Type	All Results
Nodes Results Type	All Results	Report Average Results?	False

Explicit Solver

Routing Method	Dynamic Wave	Minimum Conduit Slope	0.000 m/m
Surcharge Method	Extran	Use Bentley Transition Equation?	False
Allow Ponding at Gravity Structures	True	SWMM Pattern Mode	Use SWMM Patterns.
Skip Steady State Periods?	False	Solver Compatibility	SWMM (BENTLEY 5.1.015)
Apply SWMM Control Set?	False		

Gravity Hydraulics

Inlets

Inlet Transition Depth	0.00 m	Split Downstream Surface Flow Between Gutters?	False

Grating Parameters (United Kingdom)

Grating Type	Grating Parameter
P	30.000
Q	45.000
R	60.000
S	80.000
T	110.000

Pressure Hydraulics

Pressure Friction Method	Hazen-Williams

Rational Method

Use Rational Method Frequency Factors	False	Allow Runoff Coefficient to Exceed 1.0?	False

SWMM Dynamic

Head Convergence Tolerance	0.2 cm	Define Super Critical Flow	Froude And Slope
Max Trials per Time Step	8	Minimum Surface Area	0.000 ha
Inertial Terms	Keep	Time Step For Conduit Lengthening	0.0 sec
Use Variable Time Step?	True	Minimum Variable Time Step	0.5 sec
Time Step Multiplier	75.0 %	Number of Threads	4

SWMM Hydrology

SWMM Hydrologic Increment	0.250 hours	Start Sweeping On	01-01-2000
Antecedent Dry Period	0.0 days	End Sweeping On	31-12-2000
Dry Step	1.000 hours		

SWMM Interface Files

Rainfall File Mode	None	Save Hot Start File?	False
Runoff File Mode	None	Use Inflow File?	False
RDII File Mode	None	Save Outflow File?	False
Use Hot Start File?	False		

Fig. 7. Base scenario configuration using SWMM solver in SewerGEMS

International Journal of Engineering Research & Technology (IJERT)
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VI CONCLUSION

The sewer network design for Tumbigere village was developed using SewerGEMs software in conjunction with QGIS for spatial input and catchment delineation. The model encompasses catchment identification, sanitary load distribution, sizing of laterals and conduits, as well as assessments of manholes and outfalls, along with pollutant time-series analysis, all are thoroughly documented in the inventory and results section. Hydraulic evaluations demonstrate acceptable velocities, hydraulic gradeline (HGL) levels below rim elevations, and pipe dimensions that align with relevant design standards, indicating that the network has sufficient capacity under the proposed design conditions. This digital model serves as a dependable foundation for detailed design, cost estimation, construction planning, and assessing future scenarios such as storms or population growth. The final recommendations include verifying field elevations and inverts, along with making minor adjustments as necessary prior to construction.

A. Scope for Future Work

- Plan for network expansion and land-use changes, assessing impacts from new residential, commercial, or industrial areas.
- Simulate extreme storm events and climate change to evaluate system resilience.
- Align sewer design with treatment facilities and optimize for cost, energy, and hydraulic efficiency.
- Support sustainable practices and maintenance planning, including wastewater reuse, critical manhole management, and peak flow control.

VII REFERENCES

1. Central Pollution Control Board (CPCB), India. Environmental Standards for Effluent Discharge. (Accessed from: www.cpcb.nic.in)
2. Dawood, Anwer Hazim, and Dana Khider Mawlood. "Design of Storm Sewer System for Mass City Using Bentley SewerGEMS Software." Journal of Studies in Science and Engineering 4.1 (2024): 44-60.
3. Gupta, Mohit, P. Rao, and K. Jayakumar. "Optimization of integrated sewerage system by using simplex method." VFSTR J. STEM 3.1 (2017): 2455-3062.
4. Metcalf & Eddy (2014). Wastewater Engineering. McGraw-Hill. Chapter 2.
5. Ministry of Housing and Urban Affairs (MoHUA), Govt. of India. National Policy on Faecal Sludge and Septage Management (2017).
6. Murugesh Katti, B. M. Krishna, and Kumar B. Manoj. "Design of Sanitary Sewer Network using Sewer GEMS Software" International Journal of Science, Engineering and Technology Volume 2 Issue 1: (2015):254-258.
7. N. Patel and A. Parmar, "Design of Sewer Network: A Review," Journal of Emerging Technologies and Innovative Research, vol. 6, no. 3, pp. 286-290, Mar. 2019.
8. Padgaonkar, Sourabh, Sunil Warade, and Abhijit Pendse. "Hydraulic Sewage Drainage Design for 23 Villages Newly Added in Pune Municipal Corporation by Using Sewergems Software." (2023).
9. P. K. Gajre and D. G. Regulwar, "Design of Sewer Network: A Case Study," International Journal for Research Trends and Innovation, vol. 9, no. 6, pp. 539-545, June 2024.
10. Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2014). Wastewater Engineering: Treatment and Resource Recovery (5th ed.). McGraw-Hill Education.
11. UNESCO (2017). Wastewater: The Untapped Resource. United Nations World Water Development Report.