Grenze International Journal of Engineering and Technology, June Issue

Design and Hydraulic Optimization of Urban Sewer Network, for Shegaon City

A.V. Rasekar[1], R.M. Bhagat[2], H.M. Warhade[3], A.S. Kurzekar[4], Y.P. Kherde[5] and R.A. Borkar[6]
[1-6]Civil Engineering Department, Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India
Email: aartirasekar2002@gmail.com, rmbhagat@ycce.edu, hmwarhade@ycce.edu, askurzekar@ycce.edu, ypkherde@ycce.edu, rushalborkar16@gmail.com

Abstract*— The present study includes the sewage system for both urban and rural regions located in Shegaon Taluka, District Buldana, Maharashtra. It will be designed and hydralic optimization by using sewer-GEMS software. To help the sewer designed network planning and optimization its specified tools called a Sewer-GEMS was created. This is a dyanamic modelling tool for combined and sanitary sewer system that work on different platforms, such as GIS, CAD modes. Design and hydralic optimazation of urban and rural sewer network for shegaon city based on wastewater generation and population forecasts. The hydraulic design process involves calculating flow rates, analyzing pipe diameters and slopes, and simulating overall system behaviour & also hydraulic analysis was performed to ensure adequate flow velocities, permissible depths, and efficient pipe sizing. The Pipe materials and diameters were selected to meet hydraulic requirements while reducing excavation depth and overall construction cost. The urban population have been provided with an underground sewerage system. There is an inherent need for cost optimization of such a system to enhance affordability with reduced cost. This study presents a detailed design and optimization of the sewer network for Shegaon Town, Maharashtra. This software helps simplify the design of sewer networks and saves time. The sewerage scheme is therefore designed assuming water supply as 135 litres/capita/day. The sewage contribution shall be at the rate of 108 litres/capita/day excluding infiltration. The sewer network, with an emphasis on cost-saving design. The sewer This study presents the design and also hydraulic optimization of an urban sewer network for Shegaon City based on projected population and wastewater generation.

***Keyword*— Sewer-GEMS, Sewer Network Design, Hydraulic Modeling, Sewage Optimization, Wastewater Management.**

I. INTRODUCTION

Modern design approaches utilize advanced computer-aided tools such as 'SEWER' for efficient planning and analysis. One of the most advanced technologies in this field is 'Info-Sewer', an ArcGIS-based software used for the design, modeling, and evaluation of sewer systems. As per CPHEEO guidelines, 80% of the total water supplied is typically converted into wastewater. Sewage is categorized into two types: black water, which originates from toilets, and grey water, which comes from household sources other than toilets. Sewerage networks are an important part of the infrastructure of any society. The main purpose of providing the sewer network is to carry away sanitary waste from a municipal area in such a way that it does not cause any public health related problems [1-8].

Grenze ID: 01.GIJET.12.2.94_22

A network is designed with conduit & manhole provision accordingly using AutoCAD software. In Sewer-GEMS software, the program selects automatically pipe diameters by considering the flow in the pipe velocity and gradient requirements. Parameters like discharge, velocity, ground level, invert level and depth of cut are calculated using the software [9]. Sewage contains macro-pollutants and micro-pollutants, and may also incorporate some municipal solid waste and pollutants from industrial wastewater [10].

A. Background

Shegaon is one of the fastest growing municipal towns in Buldana District of Maharshtra State (Fig .1). The town is a tehsil head quarter of Buldana district. Shegaon is located around 41 Km northwest of Akolain Maharashtra at 20°45'N latitude & 76°40' E longitude at a height of 274 m above MSL. The town is located at an average elevation of 270 m above mean sea level. The minimum and maximum contour level of town are 260 m and 279 m as per enclosed contour map attached in the drawing sheets.There is no existing sewerage system in the project area of Shegaon town. Waste water is directly disposed into Nalla. Under Nagarotthan yojana, total area of 116 Km is considered. In order to provide infrastructure and environmental safety, Maharashtra Jeevan Pradhikaran, Government of Maharashtra has decided to proposed new STP of Capacity 8.5 MLD and 2.5 MLD as well as sewerage network system for the remaining newly developed areas of Shegaon. The figure below the displays the proposed study area.

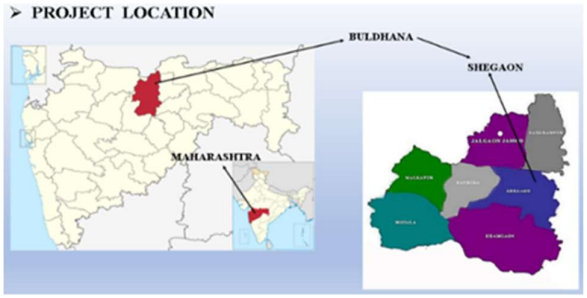

Figure 1. Project Location Map

Figure 2. Sewer Network Plan

The maps illustrate the project location and sewer network layout for Shegaon town in Buldhana district, Maharashtra. Figure-1 highlights Shegaon's geographical position within the state, while Fig. 2 presents the proposed sewer network divided into three zones, showing pipelines, and sewage treatment plant locations for efficient wastewater management.

A. Objective

- To Assess site conditions such as topography, and open drainage infrastructure.
- To design a comprehensive sewerage network covering area, ensuring proper gradients, self-cleansing velocity, and adequate capacity.
- To develop a hydraulic model to simulate flow conditions under various stages.
- To optimize the hydraulic performance of the sewer network using advanced hydraulic modelling techniques.

B. Literature Review

Demonstrated the use of Sewer-GEMS V8i for accurate hydraulic modelling; achieved self-cleansing velocity and cost-effective network layout [1]. Performed hydraulic analysis for Tumkur using Sewer-GEMS; optimized slopes for self-cleansing and ensured reliable performance [2]. Analysed and designed a sewer network using Sewer-GEMS; optimized pipe diameter and slope for cost-effective design [3]. Designed an economical sewer network using Sewer-GEMS; population forecast and hydraulic analysis performed; RCC NP3 pipes found suitable; design ensured optimal flow and velocity [4]. Developed an optimization algorithm for cost-effective and efficient sewerage network design [5]. Demonstrated effective hydraulic design ensuring proper slope and self-cleansing velocity. Designed a sewerage network for Nira village using Sewer-GEMS; achieved accurate hydraulic modelling-maintained velocity between 0.6–1.0 m/s; proved the software's efficiency for rural sewerage design [6]. Designed a sewer network using Sewer-CAD V8i software; achieved efficient hydraulic design with optimal diameters 150–200 mm, 64% of manholes maintained self-cleansing velocity; software ensured accuracy and reduced manual iterations [7].

II. MATERIALS AND METHOD

The flowchart of the methodology shown below illustrates the systematic process followed in the proposed work

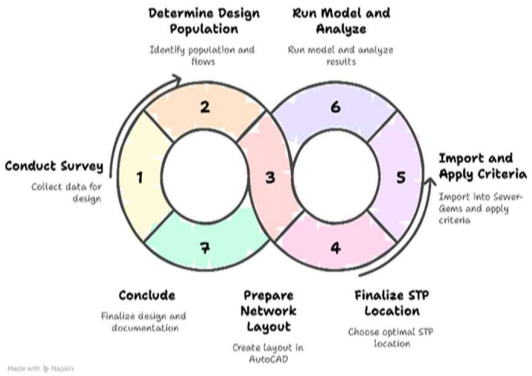

Figure 3. Methodology flow chart for sewer network design

Shown the Fig. 3, It presents a step-by-step process for sewer network design, including data collection, design determination, layout preparation, STP location finalization, model simulation & conclude.

A. Conduct survey

Shegaon is located around 41 Km northwest of Akola Maharashtra at 20°45'N latitude & 76°40' E longitude at a height of 274 m above MSL. Shegaon is Municipal Council in Buldana district. There are 15 Prabhags in whole of shegaon and each Prabhag remarked with population based on 2011 census. Total area of 116 Km is considered. Shegaon town is the fastest growing medium size town in Buldana district with an area of 839.7 Ha and a population of 59672 souls as per Census 2011. To obtain detailed information about the topographical features, a reconnaissance survey followed by a detailed survey was carried out, as shown in Table.I

TABLE I. THE TOTAL CONTRIBUTING POPULATION FOR SHEGAON

Sr. No.	Prabhag. No.	Population-2011
1	Prabhag-1	4599
2	Prabhag-2	4534
3	Prabhag-3	4887
4	Prabhag-4	4385
5	Prabhag-5	4466
6	Prabhag-6	4511
7	Prabhag-7	4380
8	Prabhag-8	4445
9	Prabhag-9	4278
10	Prabhag-10	4739
11	Prabhag-11	4582
12	Prabhag-12	4852
13	Prabhag-13	4713
14	Prabhag-14	4642
15	Prabhag-15	4374
	Total	68387

Above total No. I Contributing Population for Shegaon –The 2011 ward-wise population distribution of Shegaon, with a total population of 68,387 across 15 Prabhags.

B. Data collection

The field data required for the design network of the sewerage system such as details of existing and proposed water supply, the ward wise population as per census, development plan etc. has been collected from the Shegaon Municipal Council, Also the geographical information of the town is considered to understand the general slope of the ground which helps in finalized the alignments and directions of the sewers.

Town & village Populations:- last 5 decades for town population & last 3 decades for village population required data is available as tabulated form

TABLE II. THE POPULATION OF SHEGAON TOWN IN THE PREVIOUS 5 DECADES & SHEGAON VILLAGE IN THE PREVIOUS DECADES

Year	Population	Year	Population
1971	25993	-	-
1981	31580	-	-
1991	42492	1991	1116
2001	52423	2001	3553
2011	59672	2011	8715
Total	212160	Total	13384

Show the table II, A town population growth in Shegaon from 25,993 in 1971 to 59,672 in 2011, indicating rapid urban development. This rising trend highlights the need for improved urban infrastructure and planning. The population growth of Shegaon village, which increased from 1,116 in 1991 to 8,715 in 2011, indicating rapid rural expansion and development over the decades.

TABLE III. THE DETAILS OF THE PROPOSED SHEGAON SEWERAGE SCHEME

Year	Shegaon Town	Gramin Population	Total Forcasted
2025	74,266	15,667	89,933
2040	92,624	21,267	1,13,891
2055	1,14,617	27,116	1,41,733

Presents the proposed Shegaon sewerage scheme, showing table III, a projected rise in total population from 89,933 in 2025 to 1,41,733 in 2055, indicating the need for future-ready sewerage infrastructure.

TABLE IV. TOTAL SEWAGE GENERATION AND SEWERAGE FLOWS FOR SHEGAON INCLUDING INFILTERATION

Sr. No.	Particulars	Unit	Base Year 2025	Intermediate Year 2040	Ultimate Year 2055
1	Forecasted Population	nos	89933	113891	141733
2	Sansthan Demand (Floating Population)	MLD	5	10	20
3	Sansthan Population	nos	37037	74074	148148
4	Sansthan Sewerage Generation	MLD	4	8	16
5	Domestic Per Capita Sewage Generation Rate Considered (135 LPCD*80% of Water Supply Rate = 108LPCD)	LPCD	108	108	108
6	Sewerage Demand Calculated	MLD	9.71	12.3	15.31
7	Sewerage Demand Considered for Design	MLD	13.71	20.3	31.31
8	Peak Flow without infiltration MLD	MLD	7.95	8.84	10.32
9	Peak Flow with infiltration MLD	MLD	8.34	9.28	10.83
10	Average Flow with infiltration MLD	MLD	3.80	4.22	4.91

Represent the above table IV, The total sewage generation for Shegaon Town is projected to increase from 13.71 MLD in 2025 to 31.31 MLD in 2055, mainly due to population growth and increased sanitation demand. This table summarizes the average and peak sewerage flows for different design years, with infiltration considered for the final sewerage system planning.

TABLE V. DEMAND AS PER DEVELOPMENT PLAN OF SHEGAON

Development Demand					
Place	Manhole No.	Population	Water Demand		Sewage Generation
Engg clg	MH-160	400000	2962.96	2963	0.320004
Akot road	MH-160	400000	2962.96	2963	0.320004
Khamgaon	MH-160	500000	3703.7	3704	0.400032
Nageri road	MH-14	500000	3703.7	3704	0.400032
Vishwa	MH-82	1200000	8888.89	8889	0.960012
Anand vihar	MH-29	1200000	8888.89	8889	0.960012
Hospital	MH-35	600000	4444.44	4445	0.48006
		4.8		35557	3.840156

Above table V, The development the development plan projects future water demand and sewage generation for major zones t plan projects future water demand and sewage generation for major zones of Shegaon.
Areas like Vishwa and Anand Vihar show the highest demand due to dense development, while other zones have moderate needs.
The total estimated water demand is 35,557 m^3/day, with 3.84 MLD of sewage generation.

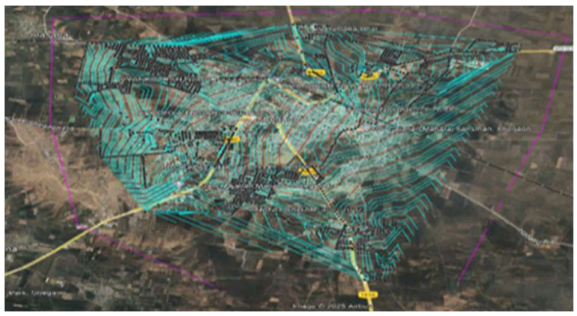

Figure 4. Contour Map Overlaid on satellite

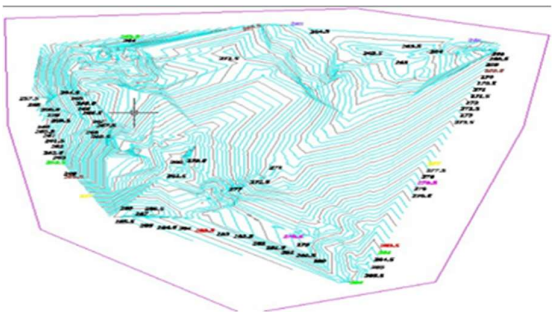

Figure 5. Elevation points connected to a terrain surface model

Contour Map and Terrain Surface Model The fig. 4 & 5, as depict the contour map overlaid on a satellite image and the terrain surface model created from elevation points, showing ground topography, elevation variations, and drainage patterns useful for sewer network planning

C. Prepare Network Layout in AutoCAD with Flow Directions

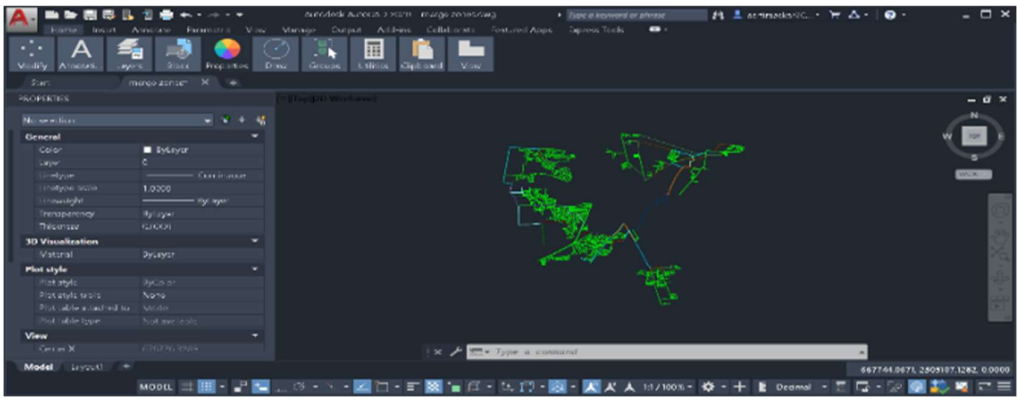

Figure 6. Flow direction network layout in AutoCAD

The sewer network layout prepared in AutoCAD, illustrating fig. 6, the alignment of pipelines with indicated flow directions. This layout helps visualize the overall network configuration and ensures proper flow routing across the drainage zones.

D. Finalized STP location

The total sewerage generation of Shegaon is 20 MLD. There are two existing STP which was built under Phase 1 & Phase 2. The existing STP are of capacity 7 MLD & 2 MLD. The existing STP is located at Unad Nallah and Gaulked Road. To counter the extra demand of 11 MLD, 2 STP are to be proposed.

TABLE VI. PROPOSED STP LOCATIONS AND CAPACITIES

Total STP Capacity	11 MLD
Proposed STP at local Nalla Gaulkhed (Gat No- 381,382)	2.5 MLD
Proposed STP at Unad Nalla (Gat No-774)	8.5 MLD

The illustrates above table VI, the proposed Sewage Treatment Plants (STPs) in the study area one at Local Nalla Gaulkhed (Gat No. 381, 382) with a capacity of 2.5 MLD, and another at Unad Nalla (Gat No. 774) with a capacity of 8.5 MLD, totaling 11 MLD for the overall sewage treatment system.

III. RESULTS AND DISCUSSION

This section presents the outcomes obtained from the optimized. The optimized pipeline network for Zone-1,2,3 (Conduit and manhole) was optimized for parameters. The classification of pipes based on these parameters is presented in Tables below. The results indicate that the optimized design achieves efficient flow distribution.

TABLE VII. (ZONE 1 CONDUIT) PIPELINE NETWORK OPTIMIZATION FOR DIA, PIPE CLASS, SLOPE, AND DEPTH CLASSIFICATION

Label	Start Node	Stop Node	Length (Scaled) (m)	Dia meter (mm)	Pipe Class	Depth (Maximum) / Rise (%)	Slope (Calculated) (1/S)	Manning's
CO-1	MH-1	O-7	13.6	300	RCC-NP4	52.6	360.003	0.013
CO-2	MH-2	MH-1	33.8	300	RCC-NP4	56.3	360.003	0.013
CO-3	MH-3	MH-2	40	300	RCC-NP4	56.5	360.003	0.013
CO-4	MH-4	MH-3	51.6	300	RCC-NP4	56.5	360.003	0.013
CO-5	MH-5	MH-4	54.6	250	DWC- SN8	71.6	360.003	0.013
CO-6	MH-6	MH-5	55.4	250	DWC- SN8	75.4	360.003	0.013
CO-7	MH-7	MH-6	50.3	250	DWC- SN8	75.4	360.003	0.013
CO-8	MH-8	MH-7	59.9	250	DWC- SN8	75.4	360.003	0.013
CO-9	MH-9	MH-8	59.5	250	DWC- SN8	75.4	360.003	0.013
CO-10	MH-10	MH-9	63.4	250	DWC- SN8	75.4	360.003	0.013

Showing above table VII, The optimized Zone 1 sewer conduit design with 250 mm DWC-SN8 and 300 mm RCC-NP4 pipes. The network maintained ensure depths and slope (52.6–75.4%), performance by effective flow and self-cleansing.

TABLE VIII. (ZONE 1 MANHOLES) PIPELINE NETWORK OPTIMIZATION FOR ELEVATION, FLOW, & DEPTH CLASSIFICATION

Label	Elevation (Ground) (m)	Elevation (Rim) (m)	Elevation (Invert) (m)	Flow (Total In) (MLD)	Flow (Total Out) (MLD)	Depth (Structure) (m)
MH-1	257.01	257.01	251.89	3.182	3.182	5.13
MH-2	257.05	257.05	251.98	3.182	3.182	5.07
MH-3	257.09	257.09	252.09	3.181	3.182	5
MH-4	257.15	257.15	252.24	3.181	3.181	4.91
MH-5	257.16	257.16	252.39	2.936	2.936	4.77
MH-6	257.16	257.16	252.54	2.936	2.936	4.62
MH-7	257.17	257.17	252.68	2.936	2.936	4.49
MH-8	257.18	257.18	252.85	2.935	2.936	4.33
MH-9	257.18	257.18	253.01	2.935	2.935	4.17
MH-10	257.19	257.19	253.19	2.935	2.935	4

The presents the table VIII, Optimized manhole parameters for Zone 1, including ground, rim, and invert elevations, along with flow and depth details. The manhole depths range from 4 m to 5.13 m, indicating a gradual decrease along the flow direction, ensuring smooth hydraulic performance and efficient conveyance of sewage through the network.

TABLE IX. (ZONE 2 CONDUIT) PIPELINE NETWORK OPTIMIZATION FOR DIA, PIPE CLASS, SLOPE, AND DEPTH CLASSIFICATION

Label	Start Node	Stop Node	Length (Scaled) (m)	Diameter (mm)	Pipe Class	Depth (Max) / Rise (%)	Slope (Calculated) (1/S)	Manning's
CO-1	MH-2	O-7	17.1	350	RCC-NP3	57.2	282.089	0.013
CO-2	MH-3	MH-2	44.3	350	RCC-NP3	59.1	282.092	0.013
CO-3	MH-1	MH-4	57.1	350	RCC-NP3	59.1	282.092	0.013
CO-4	MH-4	MH-3	69.6	350	RCC-NP3	59.1	282.092	0.013
CO-5	MH-6	MH-1	49.3	300	RCC-NP4	69.4	282.076	0.013
CO-6	MH-5	MH-7	57.5	300	RCC-NP3	69.7	282.076	0.013
CO-7	MH-7	MH-6	67.4	300	RCC-NP3	69.7	282.076	0.013
CO-8	MH-9	MH-5	40.9	300	RCC-NP3	71.7	341.437	0.013
CO-9	MH-10	MH-9	72.9	300	RCC-NP3	73.8	341.442	0.013
CO-10	MH-11	MH-10	86.5	300	RCC-NP3	73.9	341.499	0.013

The presents table IX, optimized pipeline parameters for Zone-2 conduit , including conduit length, diameter, and slope, with different diameter between the 300 and 350 mm, , and belong to the RCC-NP3 class. Which sufficient flow capacity and structural strength. Uniform flow condition although depth is calculated slope and manning's coefficient confirm.

TABLE X. (ZONE 2 MANHOLES) PIPELINE NETWORK OPTIMIZATION FOR ELEVATION, FLOW, AND DEPTH CLASSIFICATION

Label	Elevation (Ground) (m)	Elevation (Rim) (m)	Elevation (Invert) (m)	Flow (Total In) (MLD)	Flow (Total Out) (MLD)	Depth (Structure m)
MH-1	261.54	261.54	258.27	5.826	5.826	3.27

MH-2	259.23	259.23	257.66	5.826	5.826	1.57
MH-3	259.83	259.83	257.82	5.826	5.826	2.01
MH-4	260.77	260.77	258.06	5.826	5.826	2.7
MH-5	261.42	261.42	258.88	4.896	4.896	2.54
MH-6	261.51	261.51	258.44	4.896	4.896	3.06
MH-7	261.46	261.46	258.68	4.896	4.896	2.78
MH-8	261.82	261.82	259.8	4.79	4.79	2.02
MH-9	261.47	261.47	259	4.79	4.79	2.47
MH-10	261.57	261.57	259.22	4.79	4.79	2.35

The optimized manhole data for Zone 2, is display table X, including with flow variation and ground ,rim,invert elevations. Flow is constant across the manholes, but structural depths (1.57–3.27 m) of well-graded agilment that are smooth hydralic performance and enough sewage conveyance.

TABLE XI. (ZONE 3 CONDUIT) PIPELINE NETWORK OPTIMIZATION FOR DIA,PIPE CLASS, SLOPE, & DEPTH CLASSIFICATION.

Label	Start Node	Stop Node	Length (Scaled) (m)	Diameter (mm)	Pipe Class	Depth (Maximum) / Rise (%)	Slope (Calculated) (1/S)	Manning's
CO-1	MH-1	O-1	81.5	700	RCC-NP4	56.8	16,29,195	0.013
CO-2	MH-2	MH-1	54.2	600	RCC-NP4	49.1	8,219	0.013
CO-3	MH-3	MH-2	54.2	600	RCC-NP3	52.8	4,33,937	0.013
CO-4	MH-4	MH-3	54.20	600	RCC-NP3	56.1	4,33,937	0.013
CO-5	MH-5	MH-4	54.2	600	RCC-NP3	56.1	4,33,937	0.013
CO-6	MH-6	MH-5	54.2	600	RCC-NP3	56.1	4,33,937	0.013
CO-7	MH-7	MH-6	54.2	600	RCC-NP3	56.1	4,33,937	0.013
CO-8	MH-8	MH-7	54.2	600	RCC-NP3	56.1	4,33,937	0.013
CO-9	MH-9	MH-8	54.2	600	RCC-NP3	56.1	4,33,937	0.013
CO-10	MH-10	MH-9	54.2	600	RCC-NP3	56.1	4,33,937	0.013

The presents table XI, optimized pipeline parameters for Zone 3, where the majority conduits use RCC-NP3 and RCC-NP4 pipes with diameters of 600–700 mm. The design ensures uniform slope and smooth hydraulic gradient throughout the network. Depth variations and Manning's coefficient (0.013) indicate efficient flow characteristics and structural reliability across all conduits.

TABLE XII. (ZONE 3 MANHOLES) PIPELINE NETWORK OPTIMIZATION FOR ELEVATION, FLOW, DEPTH AND CLASSIFICATION

Label	Elevation (Ground) (m)	Elevation (Rim) (m)	Elevation (Invert) (m)	Flow (Total In) (MLD)	Flow (Total Out) (MLD)	Depth (Structure) (m)
MH-1	266.73	266.73	258.4	23,960	23,960	8.33
MH-2	266.88	266.88	265	18,187	18,187	1.88
MH-3	267.02	267.02	265.13	18,186	18,187	1.89
MH-4	267.16	267.16	265.25	18,186	18,186	1.91
MH-5	267.31	267.31	265.38	18,186	18,186	1.93
MH-6	267.45	267.45	265.5	18,186	18,186	1.95
MH-7	267.6	267.6	265.63	18,185	18,186	1.97
MH-8	267.74	267.74	265.75	18,185	18,185	1.99
MH-9	267.88	267.88	265.88	18,185	18,185	2.01
MH-10	268.03	268.03	266	18,185	18,185	2.03

The optimized manhole parameters for Zone 3, showing table XII, including ground, rim, and invert elevations with corresponding flow and depth data. Flow remains consistent across the network, while structure depths (1.88–8.33 m) reflect terrain variation and ensure smooth hydraulic performance for efficient sewage conveyance.

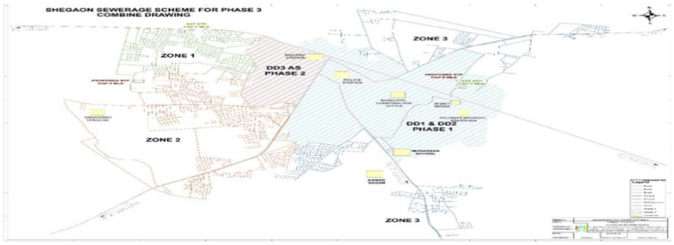

Figure 7. Shegaon Sewerage Scheme for Combine Drawing

The illustrates above fig. 7, the combined layout of the Shegaon sewerage scheme divided into Zone 1, Zone 2, and Zone 3, with designated STP locations and phase-wise implementation areas (DD1, DD2, DD3). It provides an integrated view of the sewer network alignment and connectivity across all project zones for systematic sewage management

IV. CONCLUSION

In conclusion, the optimization of the sewer network in Shegaon Town using Sewer-GEMS has offered significant understanding of its hydraulic performance and functional behavior. Network is successfully designed and optimized is done without any issues. The results are presented in a tabular format, incorporating parameters such as pipe length, slope, section type, material, diameter, and conduit class. Overflow and extreme flow is recognized automatically and hence is best suitable method to design. Observed data is as per the standards, the observed velocity is between 0.6 m/s to 0.8m/s. (0.93m/s) Actual elevation were taken and model is generated on gravity flow basis. It helps improve the overall performance of the sewer network, increases operational efficiency, and ensures proper management of wastewater systems for the community's benefit. Visual and less time-consuming software for sewerage network. Also, to counter the extra demand of 11 MLD, 2 STP are to be proposed.

REFERENCES

[1] Murugesh Katti, Dr. B. M. Krishna and Dr. B. Manoj Kumar, "Design of Sewer Network for Vijayapur city using SEWER Version 3.0 software", International journal of Scientific Development and Research ,Vol. 3, Issue 04, 2321-0613, 2015. https://library.knu.edu.af/opac/temp/11623

[2] P. S. K. Shruthi S Kannur, "Hydraulic Design & Analysis of Underground Drainage System for a Zone in Tumkur City", International Research Journal of Engineering and Technology, vol. 2, issue 5, 2395-0072, (2015). https://www.irjet.net/archives/V2/i5/IRJET-V2I558

[3] Hinal sopariya, R. L. patel, Y.P.Pathak "Analysis and Design of Sewer Network using Sewer GEMS", International journal of creative Research thoughts, vol.6, issue2, pp.2320-2882,2018. https://ijcrt.org/papers/IJCRT1812845

[4] Prof. yugandhara Ingale, Abhishek pawar, Satyajeet Patil, Yogesh Patil, Nikhil Toche, "Design of Sewer System for village using Sewer GEMS", International Journal of Recent Technology and Engineering (IJRTE) ,vol.8 , issue 7, pp. 2395-0072 ,2021. https://www.irjet.net/archives/V8/i7/IRJET-V8I7127

[5] Abhishek Pawar, Yogesh Patil, "Design Of Sewer System For Village Using Sewergems", International Research Journal of Engineering And Technology, Volume:08, Issue:07, July. https://www.irjet.net/archives/V8/i7/IRJET-V8I7127

[6] Shambhuraj Rajesh Chavan, Sandesh Sangit kumar Shitole, s. m. Mukhopadhyay "Design of Sewerage Network by using Sewer GEMS" International journal of creative Research thoughts, vol.10, issue 11, pp. 2320-2882, 2022. https://ijcrt.org/papers/IJCRT2211289.

[7] Vidhi Bhavsar et al., "Design of Sewer Network for Dolarana Vasana Village using Sewer GEMS Software," International Journal of Science Technology & Engineering, vol.4, no.2, pp.5-8,2017. https://ijste.org/Article.php?manuscript=IJSTEV4I2003

[8] Uditi Chaudhary et al., "Sanitary Gravity Sewer Design Using Sewer GEMS Software Connect Edition for Utsav Vihar, Karala," International Journal of Recent Technology and Engineering (IJRTE),vol.9, no.2, pp.598-602, 2020 http://www.doi.org/10.35940/ijrte.B3255.079220

[9] Ole Fryd, Torben Dam, and Marina Bergen Jensen, "A Planning Framework for Sustainable Urban Drainage Systems," Water Policy, vol. 14, no. 5, pp. 865-886, 2012 https://doi.org/10.2166/wp.2012.025

[10] Punam Harising Rajpurohit, and J.D. Raol, "Design of Sanitary Sewer Network for Gandhinagar City using SewerGEMS V8i Software," International Journal of Advance Research in Engineering, Science & Technology, vol. 3, no. 2, pp. 164-170, 2016 https://ijarest.org/index.php/ijarest/article/download/437/421