

# Design of Sanitary Sewer Network for District 2B, Vijayapur city using SewerGEMS V8i Software

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**Abstract-** The paper presents an advanced modeling and design software application for sewer networks – SewerGEMS V8i, which allows projects to be accomplished in a short time, with high efficiency and low costs. In the present study sewer network has to be designed for District 2B, Vijayapur city. In the design of a sewerage system the sewer network is the basic unit occurring repeatedly in the design process. Any savings during the design of this unit will affect the overall cost of the sewerage system. Bentley SewerGEMS V8i is the first and only fully-dynamic, multi-platform (GIS, CAD and Stand-Alone) sanitary and combined sewer modeling solution. With Bentley SewerGEMS V8i, we will analyze all sanitary and combined sewer system elements in one package and have the option of performing the analyses with the SWMM algorithm or our own implicit solution of the full Saint Venant equations. The hydraulic design consists in the computation of the transit and total flow and hydraulic modeling for network pipes diameters or slopes. The application provides reports, layouts, longitudinal or transversal cross sections of the pipe network, displayed in an advanced graphic system based on AutoCAD technology. With specific tools and features included, SewerGEMS V8i offers a full range of possibilities for the designer to draw, label, dimension and plotting the drawings of the sewage networks.

**Index Terms:** ArcGIS and CAD, MicroStation, Sewage, Sewer network, SewerGEMS V8i, Vijayapur city

## I. INTRODUCTION

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. It is known that urban sewerage system provide one of the basic infrastructure facilities to transport sanitary waste to sewage treatment plant. Sewerage network infrastructure conveys wastewater used by individuals, commercial and industrial establishments to wastewater treatment facilities, ultimately to be returned to the natural environment. A sewerage network is just a reverse

action of water supply network. The cost of laying a sewerage system is appreciably high compared to the water supply system. It involves a large cost with need for daily maintenance, and the operational cost is one of the major expenditures. In respect of this view, many research works are being done to design a cost effective sewerage network with the given constraints and guidelines. These difficult problems can be solved by using the computer software package SewerGEMS V8i. The computer software package SewerGEMS V8i is the most helpful tool of the purpose of designing an economic sewer network since it can give the optimum cost and practically feasible layout which can handle a large network. The program selects automatically pipe diameters by considering the flow in the pipe velocity and slope requirements.

## II. GENERAL DETAILS ABOUT THE SOFTWARE

### A. MicroStation Mode

This gives you access to all of MicroStation's drafting and presentation tools, while still enabling we to perform Bentley SewerGEMS V8i modeling tasks like editing, solving, and data management. This relationship between Bentley SewerGEMS V8i and MicroStation enables extremely detailed and accurate mapping of model features, and provides the full array of output and presentation features available in MicroStation. This facility provides the most flexibility and the highest degree of compatibility with other CAD-based applications and drawing data maintained at any organization.

### B. ArcGIS Mode

Each mode provides access to differing functionality certain capabilities that are available within ArcGIS mode may not be available when working in the Bentley SewerGEMS V8i Stand-alone Editor. All the functionality available in the Stand-alone Editor are, however, available in ArcGIS mode.

### C. AutoCAD Mode

This gives you access to all of AutoCAD's drafting and presentation tools, while still enabling you to perform Bentley SewerGEMS V8i modeling tasks like editing, solving, and

data management. This relationship between Bentley SewerGEMS V8i and AutoCAD enables extremely detailed and accurate mapping of model features, and provides the full array of output and presentation features available in AutoCAD. This facility provides the most flexibility and the highest degree of compatibility with other CAD-based applications and drawing data maintained at your organization.

### III. GENERAL INFORMATION ABOUT VIJAYAPUR CITY

#### A. Vijayapur City

Vijayapur District (Karnataka state) is situated on the South Central Railway line 213 km north of Hubballi and 96 km south of Sholapur city (in Maharashtra State). It is situated in the Belgaum Division of Indian Railways and is 192 km from Belgaum, the Divisional Headquarters. It has a population of 3,18,624 as per the 2011 Census.

#### B. Existing Water Supply and Sewerage arrangement

Vijayapur City has three piped water supply systems. Bhutnal Tank was the first water supply system constructed in 1914 on a local nalla. The total storage capacity is 1,848.75 ft spread over 50 ha. Krishna River First Stage Water Supply System was constructed in 1971 near Baluthi (now shifted to Kolhar Village in 1976 due to submergence), with back water of Almatti Irrigation dam is the source of water. The Krishna River Second Stage Water Supply System is designed to supply 27.24 MLD water to a population of 270,000 expected in year 2006 and 45.40 MLD water to a population of 350,000 expected in year 2021 at the rate of 135 lpcd. Together, the supply to the town during the summer months works to 27 MLD at 121 litres per capita per day (lpcd), gross supply – it is estimated that 30 -40 percent of water supplied is lost through transmission and distribution, with consumers receiving a net supply of 80 lpcd. Sewerage system was provided in the old part of Vijayapur town in year 1976. It was designed to cover 1,50,000 population in the city within the fort wall and for sewerage flow of 13.50 MLD. The sewer network covers about

40 percent of the CMC area and only 224 km out of a total of 565 km of roads.

#### C. Necessity of the Project

Vijayapur city had a UGD (Underground Drainage System) system since 1976, which covers 40% of the town's area. Survey results indicate that 77% of households have UGD connection, 22% have septic tank connectivity while the remaining one percent avail the services of public convenience. For wastewater disposal, approximately 40 percent of the surveyed households are connected to UGD while the remaining 60 percent dispose the sewage and sullage into roadside drains. As the development of city is very fast and hence 100% UGD connection is needed.

#### D. Design Proposal for Sewer Network

The preliminary work for a design engineer is to carry out field investigation and further to study carefully the characteristics of the study area pertaining to the road network pattern, projected population, land topography, natural barrier, existing and proposed land use, tentatively proposed site for sewage treatment plant and the outfalls etc. The master plan in "Fig.1." shows various housing unit sizes, street orientation and other civic amenities for the study area. Trunk sewer alignment has been proposed by considering the topography of the city and major obstacles like National Highway and railway track. Zoning has been done in such a way that trunk sewer line has to cross NH and Railway line at very minimal points. Based on this, entire Vijayapur CMC is divided into three main sewerage districts. A separate nomenclature has been given to Manholes as EMH for Existing Manholes, IMH for Newly Inserted Manholes in between two existing manholes and PMH for Proposed new Manholes at uncovered areas. Similarly for trunk sewers pipe number will start with T1, T2 etc, for sub mains S1, S2...S11 etc and for laterals it is P. Based on this zonal plan the pipeline corridor survey for the trunk sewers have been done and designed.

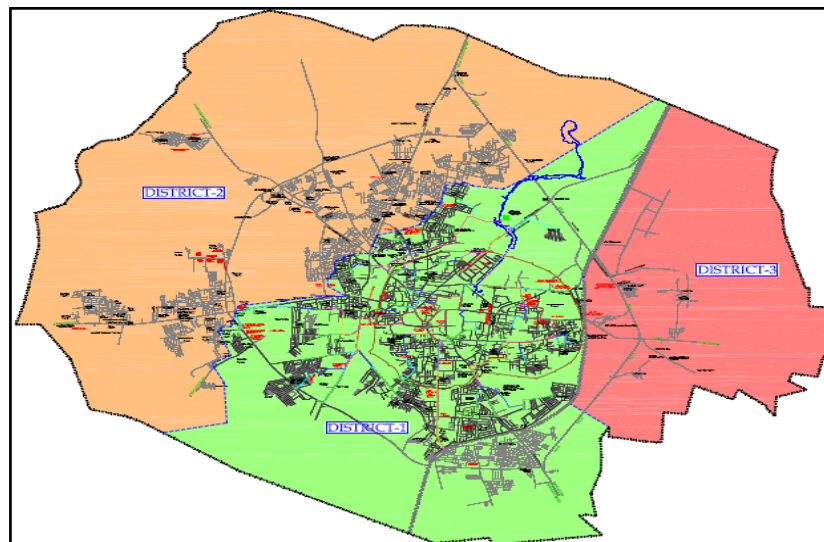


Fig. 1. Master plan for Vijayapur city

#### IV. MATERIALS AND METHODS

##### A. Data Collection

For design a Sewer network of Vijayapur city, the following data were obtained from Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC).

- 1] Collection of the population of last 6 decades of Vijayapur city.
- 2] Collection of the existing work data of head work, sewer pipeline.
- 3] Road map of Vijayapur city.
- 4] Data of previous existing Sewer network.

##### B. Population Forecast

Vijayapur population has grown from 1, 93,131 in 1991 to 2, 45,946 in 2001 indicating a growth rate of 27.35 percent. The highest and lowest population growth rates recorded were 41.74 percent during 1971-1981 and 15.98 percent during 1901-1911. The projected populations for the design horizons for 2011, 2026 and 2041 are 318624, 452665 and 624515 respectively.

##### C. Total Sewage Contribution

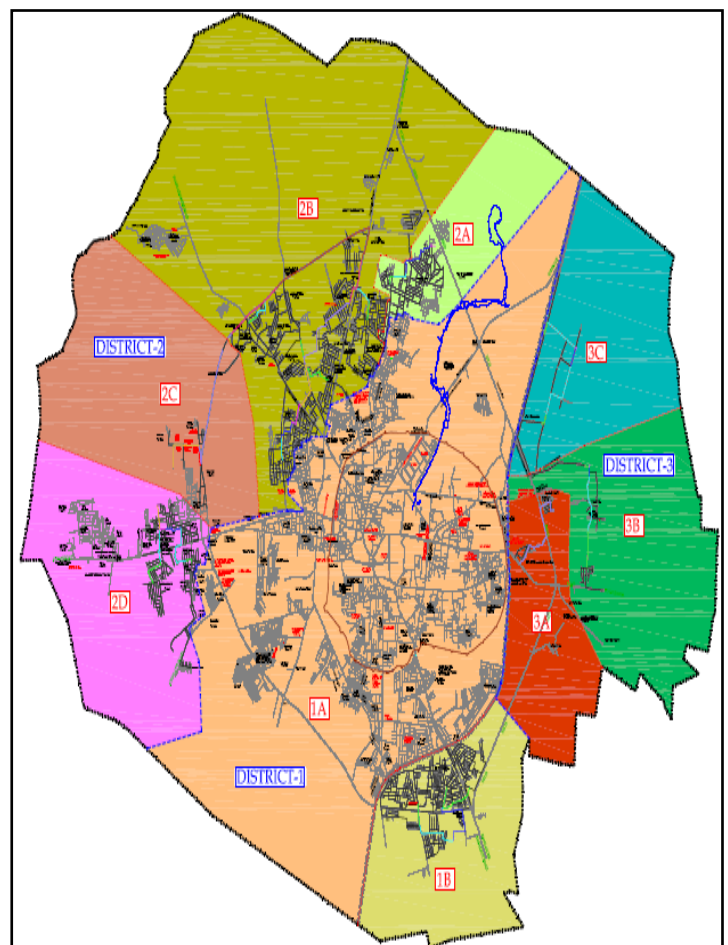
The design flows are essentially the peak flows, which is the average weather flows multiplied by a peak factor. It is agreed that the design per capita water supply shall be 100 lpcd. As per CPHEEO norms, about 80 of water supply finds its way as wastewater into sewers i.e. 80 lpcd. In addition to that 5% of domestic flow is added to account for non-domestic flows. Thus a per capita flow of 84 lpcd, including provisions for infiltration (500 litre/km/day) has been considered for the design. And table 1 gives the population projection and sewage flow calculations.

**Table 1: Population projection and Sewage flow calculations**

Design Year	No of Decades	Design Population	LPCD	Sewage Flow Generation (MLD)		
				Domestic	Non domestic/Infiltration	Total
2011	12.0	318624	80	25.49	1.27	26.76
2016	12.5	359406	80	28.75	1.44	30.19
2021	13.0	404026	80	32.32	1.62	33.94
2026	13.5	452665	80	36.21	1.81	38.02
2031	14.0	505504	80	40.44	2.02	42.46
2036	14.5	562727	80	45.02	2.25	47.27
2041	15.0	624515	80	49.96	2.50	52.46

##### D. Design Criteria

The major design criteria adopted for this project are as listed below. The per capita sewage generation is taken as 80 lpcd i.e. 80% of water supply level as suggested by CPHEEO. 5% provision is added over this to account for ground water infiltration and any other unaccounted for non domestic addition. The minimum diameter of sewer adopted is 150 mm. Materials used are Glazed Stoneware (GSW) up to 250 mm dia and depth 3 m and RCC NP3 thereafter. In crossings and



where minimum cover is not possible, encasing with RCC NP4 of higher diameter is suggested. The minimum velocity is 0.6 mps at present peak flow and peaking factor from 2.25 to 3.00 based on cumulative population as suggested in CPHEEO manual. However since it is practically not possible to ensure this in starting laterals, the sewers have been designed to have minimum slopes suggested in CPHEEO manual. Minimum cover ensured is 1.0 m (though at starting stretches with less traffic it is restricted to 0.80 m to avoid uneconomical depth subsequently) and maximum is restricted to 6 m.

## V. SEWAGE NETWORK DESIGN

### A. Laying Out a Network

SewerGEMS V8i is an extremely efficient tool for laying out a storm or sanitary sewer network. It is easy to prepare a schematic or scaled model and let SewerGEMS V8i take care of the link-node connectivity. In constructing the network for this lesson, you do not need to be concerned with assigning labels to pipes and nodes, because the software assigns labels automatically. A schematic drawing is one in which pipe lengths are entered manually, in the user defined length field. In a scaled drawing, pipe lengths are automatically calculated from the position of the pipes' bends and start and stop nodes in the drawing pane. For the purposes of this lesson, we will build a schematic model.

### B. GIS Basics

Bentley SewerGEMS V8i provides three environments in which to work: Bentley SewerGEMS V8i Modeler Mode, AutoCAD Integrated Mode, and ArcMap Integrated Mode. Each mode provides access to differing functionality—certain capabilities that are available within Bentley SewerGEMS V8i Modeler mode may not be available when working in ArcMap Integrated mode, and vice-versa. In addition, we can use ArcCatalog to perform actions on any Bentley SewerGEMS V8i database. Some of the advantages of working in GIS mode include:

- Full functionality from within the GIS itself, without the need for data import, export, or transformation
- The ability to view and edit multiple scenarios in the same geo database
- Minimizes data replication
- GIS custom querying capabilities
- Lets you build models from scratch using practically any existing data source
- Utilize the powerful reporting and presentation capabilities of GIS

### C. Features of the MicroStation Version

Bentley SewerGEMS V8i features support for MicroStation integration. We run Bentley SewerGEMS V8i in both MicroStation and stand-alone mode. The MicroStation functionality has been implemented in a way that is the same as the Bentley SewerGEMS V8i base product. In MicroStation mode, we will have access to the full range of functionality available in the MicroStation design and drafting environment. The standard environment is extended and enhanced by using MicroStation's MDL (MicroStation Development Language) client layer that lets you create, view, and edit the native Bentley SewerGEMS V8i network model while in MicroStation. MDL is a complete development environment

### E. Zones and Subzones

Based on the topography of peripheral areas in each main district, sub-zones have been demarcated district-wise, areas which are not draining sewage by gravity to the corresponding main district. Vijayapur city has been divided into three drainage districts. As shown in "Fig. 2

**Fig. 2. Zones and Subzones**

that lets applications take full advantage of the power of MicroStation and MicroStation-based vertical applications. MDL can be used to develop simple utilities, customized commands or sophisticated commercial applications for vertical markets. Some of the advantages of working in MicroStation mode include:

- Lay out network links and structures in fully-scaled mode in the same design and drafting environment that you use to develop your engineering plans.
- We will have access to any other third party applications that you currently use, along with any custom MDL applications.
- Use native MicroStation insertion snaps to precisely position Bentley Sewer-GEMS V8i elements with respect to other entities in the MicroStation drawing.
- Use native MicroStation commands on Bentley SewerGEMS V8i model entities with automatic update and synchronization with the model database.
- Control destination levels for model elements and associated label text and annotation, giving us control over styles, line types, and visibility of model elements.

### D. Working in AutoCAD Mode

The AutoCAD functionality has been implemented in a way that is the same as the SewerGEMS V8i base product. Once you become familiar with the stand-alone mode, we will not have any difficulty using the product in AutoCAD mode. Some of the advantages of working in AutoCAD mode include:

- Layout network links and structures in fully-scaled mode in the same design and drafting environment that we use to develop engineering plans. We will have access to any other third party applications that we currently use, along with any custom LISP, ARX, or VBA applications that we developed.
- Use native AutoCAD insertion snaps to precisely position Bentley SewerGEMS V8i elements with respect to other entities in the AutoCAD drawing.
- Use native AutoCAD commands such as ERASE, MOVE, and ROTATE on Bentley SewerGEMS V8i model entities with automatic update and synchronization with the model database.
- Control destination layers for model elements and associated label text and annotation, giving us control over styles, line types, and visibility of model elements.

### E. Fundamental Solution of the Gravity Flow System

With increasing urbanization and urban renewal impacts driving the drainage and water quality regulatory framework,

the design and analysis of storm water systems are becoming increasingly complex. The hydraulics characteristics of a drainage system often exhibit many complicated features, such as tidal or other hydraulic obstructions influencing backwater at the downstream discharge location, confluence interactions at junctions of a pipe network, interchanges between surcharged pressure flow and gravity flow conditions, street-flooding from over-loaded pipes, integrated detention storage, bifurcated pipe networks, and various in line and offline hydraulic structures. The time variations of the storm drainage design flow event are increasingly important in verifying total performance and achieving a measure of regulatory or design policy compliance. To better understand these complicated hydraulic features and accurately simulate flows in a complicated storm water handling system hydrodynamic flow models are necessary. To simulate unsteady flows in storm water collection systems, numerical computational techniques have been the primary tools, and the results from numerical models are widely used for planning, designing and operational purposes. Since an urban drainage system can be composed of hundreds of pipes and many hydraulic control structures, the hydraulics in storm system can exhibit very complicated flow conditions. Consequently the numerical stability, computational performance, capabilities and robustness in handling complicated hydraulic conditions and computational accuracy are the major factors when deciding which approach to use to solve the hydraulic system.

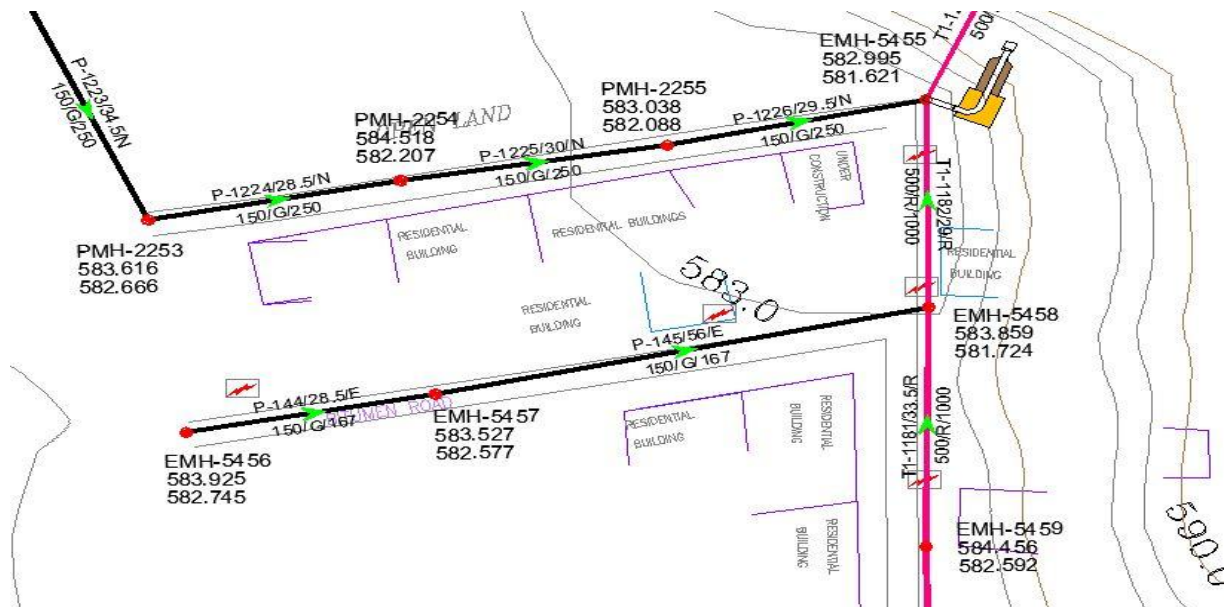
Although many numerical methods have been developed to simulate the unsteady flows in sewer and storm water systems, including those based on explicit numerical schemes and those based on implicit schemes, limitations in most of models exist. SewerGEMS V8i features engines capable of solving the dynamic solution using both schemes. Users may select to either use EPA SWMM's native explicit solver or a custom implicit solver as more fully described in this section. The implicit solver is the default solver used in SewerGEMS V8i.

## VI. RESULTS AND DISCUSSIONS

SewerGEMS V8i is an extremely efficient tool for laying out a storm or sanitary sewer network. It is easy to prepare a schematic or scaled model and let SewerGEMS V8i take care of the link-node connectivity. In constructing the network for this lesson, you do not need to be concerned with assigning labels to pipes and nodes, because the software assigns labels automatically. A schematic drawing is one in which pipe lengths are entered manually, in the user defined length field. In a scaled drawing, pipe lengths are automatically calculated from the position of the pipes' bends and start and stop nodes in the drawing pane. District 2B, Vijayapur city has designed for the large network of 57,854 meters, in that 270 meters of sewer network can be shown Fig.3 and the results are tabulated in table 2.

**TABLE 2: SewerGEMS V8i results**

Pipe No.	From MH	To MH	Length (m)	Peak Flow (2041) (LPS)	Proposed Diameter (mm)	Proposed slope (1 in S)	d/D Ratio	Velocity (2041) (m/s)	Excavation Depth (m)
P-144	EMH-5456	EMH-5457	28.5	0.1458	150	167	0.07	0.23	1.13
P-145	EMH-5457	EMH-5458	56	0.2575	150	167	0.10	0.29	1.35
T1-1181	EMH-5458	EMH-5455	33.5	107.7726	500	1000	0.65	0.79	1.76
T1-1182	EMH-5458	EMH-5455	29	108.1178	500	1000	0.65	0.79	1.89
P-1223	PMH-2252	PMH-2253	34.5	3.4037	150	250	0.39	0.53	1.20
P-1224	PMH-2253	PMH-2254	28.5	3.5141	150	250	0.40	0.53	1.52
P-1225	PMH-2254	PMH-2255	30	3.6174	150	250	0.40	0.53	1.75
P-1226	PMH-2255	EMH-5455	29.5	3.7226	150	250	0.41	0.54	1.05



**Fig. 3. Sewer Network**

## VII. CONCLUSIONS

The efficiency of using the SewerGEMS V8i software for sanitary sewer network design is given by:

- Less time spent to create the drawings by using the tools for labeling the system parts, updating data automatically for layout and longitudinal profile with the modifications we make along the designing process, calculating the pipe diameters automatically, using the features for creating the plotting drawings.
- This process is easy and simple for the design of sewerage networks. And it helpful for designing large sanitary sewer network.
- A map containing pipe details, velocity, elevations and flow can be directly obtained from SewerGEMS V8i. SewerGEMS V8i will maintain the minimum and maximum velocity condition.
- Customized representation and information shown both in the layout and longitudinal profile that can be used for any of our projects.
- Final drawings produced into a “.dwg” format which is the most generally accepted file format for engineers.

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