

COMPARATIVE STUDY OF SEWER VERSION 3.0 AND SEWERGEMS V8I SOFTWARES FOR SANITARY SEWER NETWORK DESIGN

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ABSTRACT

The paper gives a comparative study of SEWER Version 3.0 and SewerGEMS V8i softwares for sanitary sewer design. SewerGEMS V8i, which allows projects to be accomplished in a short time, with high efficiency and low costs. 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. The computer program "SEWER Version 3.0" uses the manning's equation for the heuristic design of sanitary sewer system. It is suitable for the design of small bore sewers as well as large diameter conventional sewers and can handle up 800 pipes. The program assists in the design of bedding and also calculate slope. The program also gives the cost abstract for the designed sewer network. The comparison of velocity, d/D ratio and pipe diameter can be done by taking one design example, for the outcomes got for SEWER Version 3.0 and SewerGEMS V8i.

Index Terms: ArcGIS and CAD, d/D ratio, MicroStation, SEWER Version 3.0, Sewage, Sewer network and SewerGEMS V8i

1. 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 coast 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 packages like SEWER Version 3.0 and 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. The computer program "SEWER Version 3.0" uses the manning's equation for the heuristic design of sanitary sewer system. It is suitable for the design of small bore sewers as well as large diameter conventional sewers and can handle up 800 pipes. The program also gives the cost abstract for the designed sewer system. In heuristic methodology the constraints are less. Hence, in this study the computer program software package "SEWER Version 3.0" based on heuristic approach making use of dynamic programming also has been made use of for the design of sewer system.

2. GENERAL DETAILS ABOUT THE SewerGEMS V8i SOFTWARE

2.1 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.

2.2 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.

2.3 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.

3. GENERAL DETAILS ABOUT THE SEWER VERSION 3.0 SOFTWARE

3.1 GENERAL

The program SEWER Version 3.0 is a menu driven computer program written in quick Basic language IBM-PC microcomputer. It was developed by U.N.D.P. which optimizes heuristically a sewer network for a given layout, flow and pipe diameter thereby minimizing the excavation. For the hydraulic design of the pipe, SEWER uses Manning's equation, which is given as

$$V = (1/n)R^{2/3}S^{1/2}$$

Where,

- V = Design velocity in m/s
- n = Manning's roughness coefficient
- R = Hydraulic radius in m
- S = Hydraulic slope

One of the advantages of using SEWER Version 3.0 is that it can help design a large network up to 800 pipes thereby providing the facility of introducing the pumping station for the condition where the excavation depth is beyond the specific level and the provision of the graphical display of the longitudinal section of the pipe line. Because of these features, the program is selected for the design of sewer network thereby limiting design constraints like maximum and minimum velocity, maximum and minimum cover, depth and slopes.

During the design process, SEWER identifies a set of feasible diameters out of the set of specified commercially available diameter for each pipe subject to the condition that the velocity requirement and slope requirement are satisfied. This begins with the

maximum permissible ratio of depth of flow in pipe(d) to the diameter of pipe(D) while working on the pipe slope and tries to meet the constraints and progression of pipe diameter. It designs the pipe slope within the given range. The program output consists of the pipe diameter, velocity flow, slope, excavation depth of pipe and pipe cost etc.

3.2 PROGRAM RUN

If all the data of the network entered are correct then the programmer can be RUN to design the network. The more complicated and larger the network, it will take more time to design. The process include renumbering of the nodes and links, assignment of flows, determination of maximum and minimum slopes, calculation of actual pipes slopes and their elevations. Determination of velocities and depths of flows in the links, checking of the minimum cover depth and reassigning the original link and node numbers. The result includes the peak flows, water depths, pipe slopes, minimum slopes. Maximum slopes and ground slopes for each link. Also the U/S and D/S ground elevations. Invert elevations and excavation depth for each link is given. In respect of nodes the total excavation depth and the difference in elevation of the highest invert entering the node and that of leaving the node is given. The total length of links in the network. The average weighted diameter and excavation depth and excavation area are also given.

The programmer compares crown elevation of connected pipes and ignores minor head losses thus the final design is only an approximation which can be refined by the design engineer. The programmer assumes that the network has only one outfall and uses manning's equation to determine the pipes slopes. It assumes that any pipe flowing at 80% full is flowing completely full. The information and data required as input for the computer results of the SEWER programmers as run in the compute etc. Data and information required as input design a SEWER network using Microcomputer. The BRANCH programmer available for SEWER design is capable of designing 800 links and 801 nodes.

The information required to be fed into the computer for the sewer design is divided into 3 major parts:

1. System information
2. Link data
3. Node data

The nodes and links can be numbered between 1 to 36000, all +ve integers. They need not be consecutive.

The system data includes the following

1. Project title
2. Unit to be adopted
3. Number of the outfall node
4. Peak factor
5. Minimum and maximum velocities
6. Manning's coefficient
7. Maximum cover depth

The link data includes the following

1. Link numbers from and to i.e. the link number of starting node and ending node
2. Length diameter of the link
3. Minimum cover depth for the link

The node data includes the following

1. Node number
2. Flow input at the node (flow inputs are entered as +ve and flow outputs are -ve the only node which have demand or output is the outfall node) whenever transitions and other changes are encountered. A junction node can be introduced.

4. SEWER NETWORK DESIGN BY SewerGEMS V8i

4.1 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.

4.2 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

4.3 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 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.

4.4 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.

4.5 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 user 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.

5. RESULTS AND DISCUSSIONS

5.1 EXAMPLE NETWORK

To illustrate sewer network design using SEWER Version 3.0 and SewerGEMS V8i, Vijayapur District (Karnataka state). It 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 20011 Census. 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. For this comparative studies, consider the District 2B, vijayapur city i.e. shown in Fig.1.

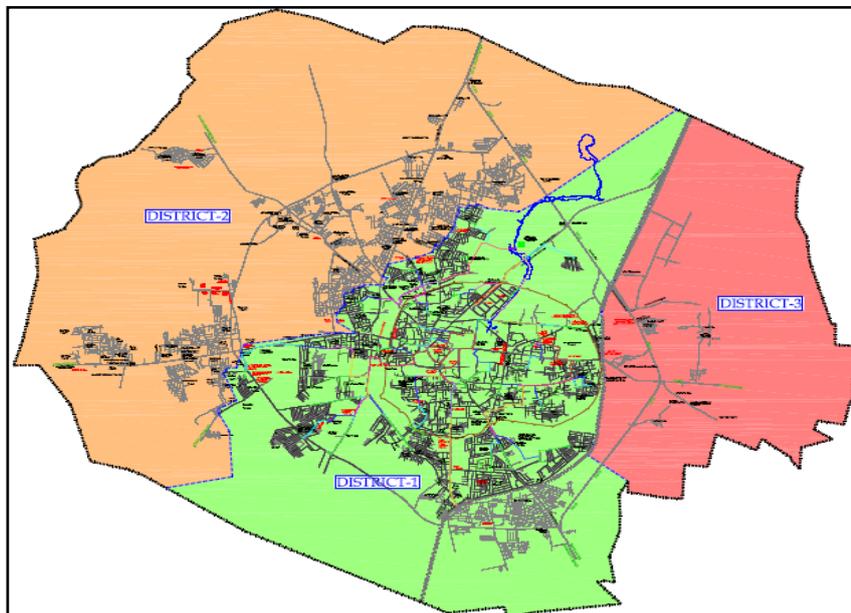


Figure 1: Master plan for Vijayapur city

5.2 COMPARISON

Comparative studies of SewerGEMS V8i and Sewer VERSION 3.0 output results can be done for each pipe. The variations of Velocities can be shown in Figure 2.

Comparison for d/D ratio in both the software is given in Figure 3 and variations of Diameter progression are shown in Figure 4.

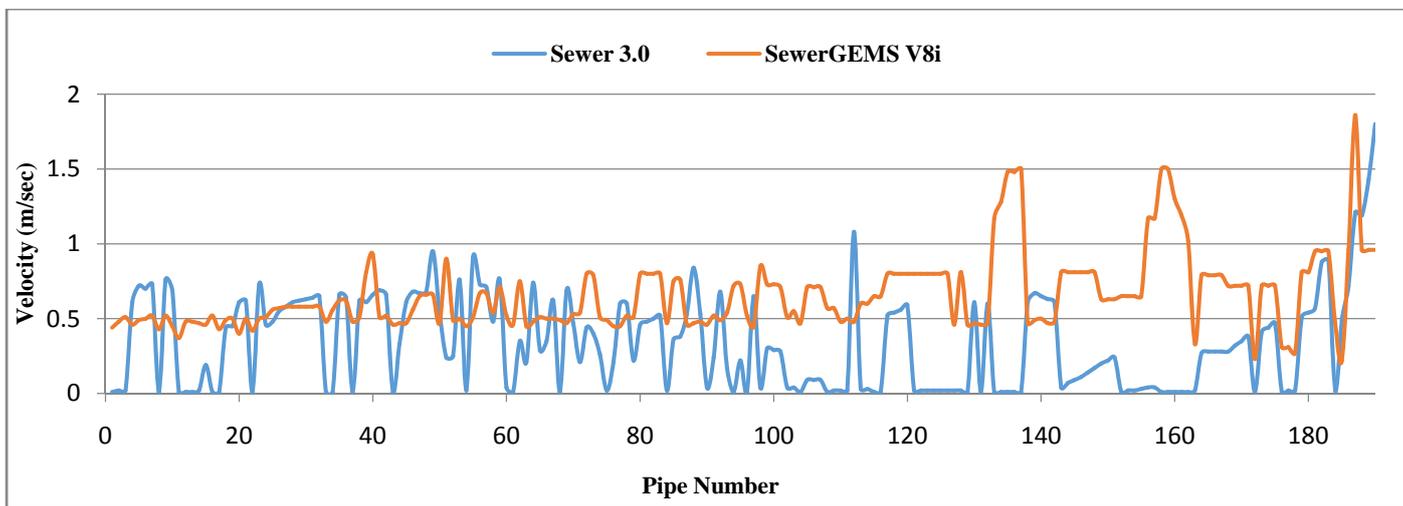


Figure 2: Velocity Comparison

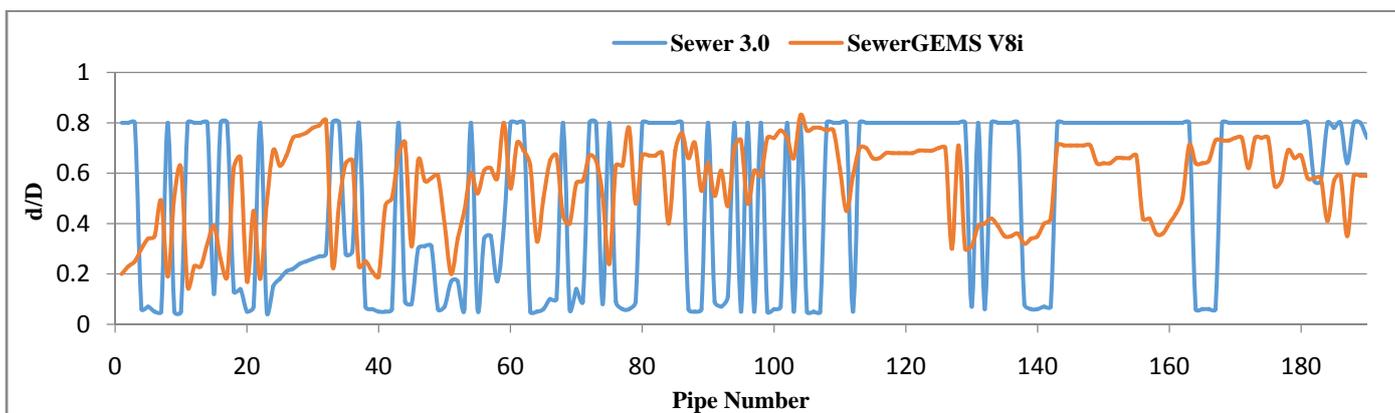


Figure 3: d/D Comparison

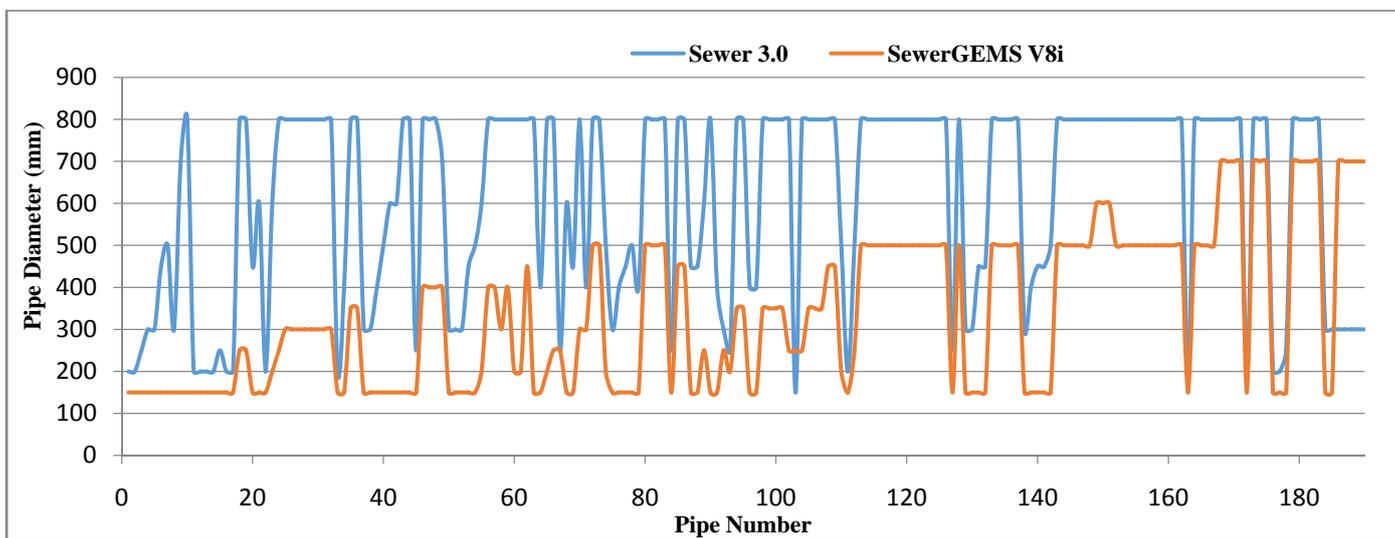


Figure 4: Pipe Diameter Comparison

6. CONCLUSIONS

The following conclusions are made after analyzing the results obtained from this study.

- The lowest diameter size option is found in SewerGEMS V8i output results.
- 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.
- Pipe slope will be very less in some of the pipes in SEWER Version 3.0.
- d/D ratio is very high in SEWER Version 3.0
- SEWER Version 3.0 directly it will give cost details of excavation and pipe materials.
- In SewerGEMS V8i, 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.

- SewerGEMS V8i is easy and simple for the design of sewerage networks. And it helpful for designing large sanitary sewer network.
- By considering all the above points, SewerGEMS V8i will give feasible and optimal results. Hence, the results obtained from SewerGEMS V8i can be recommended for the entire sewer network.

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