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Design of Sanitary Sewer Network for Gandhinagar City using SewerGEMS V8i Software

Punam Harising Rajpurohit[1], J.D. Raol[2]

[1] PG Student, M.E. (Civil) Infrastructure Engineering, L.D.R.P. Institute of Technology & Research, Gandhinagar
[2] Faculty , Department of Civil Engineering, L.D.R.P. Institute of Technology & Research, Gandhinagar

Abstract- The paper presents an advanced modeling and design software application for sewer networks – SewerGEMS V8i, that permits projects to be accomplished in an Exceedingly short time, with high efficiency and low prices. Within the present study sewer network has to be designed for Sector-2, Gandhinagar city. In the design of a sewerage system the sewer network is the basic unit occurring repeatedly in the design method. 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 StandAlone) sanitary and combined sewer modeling solution. With Bentley SewerGEMS V8i, we will analyze all sanitary sewer system elements in one package.

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.

Keywords-component: ArcGIS and CAD, MicroStation, Sewage, Sewer network, SewerGEMS V8i, Gandhinagar city

I. INTRODUCTION

Sewerage networks are an imperative part of the infrastructure of any society. The main purpose of providing the sewer network is to take 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 essential 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 sewerage system is considerably high compared to the water supply system. It involves a huge 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 means of the computer software package SewerGEMS V8i. The computer software package SewerGEMS V8i is the most helpful tool of the purpose of designing an cost-effective 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 drafting and presentation tools, while still enabling we to carry out Bentley SewerGEMS V8i modeling tasks like editing, solving, and data management. This relationship between Bentley SewerGEMS V8i and MicroStation enables extremely detailed and precise 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 maximum 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.

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 GANDHINAGAR CITY

A. *Gandhinagar City*

Gandhinagar is the capital of Gujarat state, west-central India. Gandhinagar lies on banks of the Sabarmati River. Gandhinagar occupies an area of 57 sqkm. It is about 24 km to the north east of Ahmedabad. The concept of the city is based on the grid iron pattern similar to that of historical Jaipur and Chandigarh, the grid being formed by seven roads in each direction cutting each other perpendicularly. Gandhinagar is known as second planned city in India after Chandigarh. It has a population of 2,92,797 as per the 2011 Census.

Figure 1. Road Connectivity of Gandhinagar City

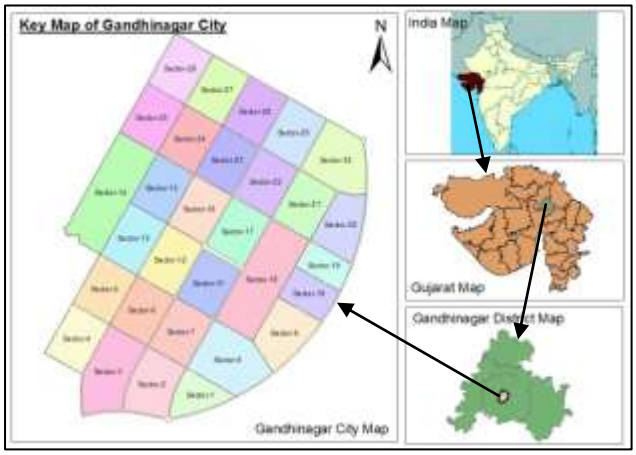

Figure 2. Key Map of Gandhinagar City

B. *Existing Water Supply and Sewerage arrangement*

As per the information of Capital Project Division, Gandhinagar, the current water supply in the city is 75 MLD. From which 55 MLD is collected from surface water and 20 MLD is sourced from groundwater source. Sewerage system was designed and constructed in 1970 in the city. The whole wastewater from city is taken by underground pipes and collected in Sargasan Drainage Pumping Station. From this Pumping Station Wastewater is pumped and transferred to Jaspur Wastewater Treatment Plant through Rising Main & Sargasan STP. But Sargasan STP utilizes 50% of its total Capacity.
The Capital Project's information points that available treatment capacity in the Jaspur wastewater treatment plant is 90 MLD. Considering that 80 percent of water supplied gets generated as wastewater, the wastewater in the Gandhinagar comes to 60 MLD.

Table 1 Existing STP Details

STP Location	Capacity	Used by Gandhinagar City	Use of wastewater
Jaspur	90 MLD	55 MLD	Agricultural
Sargasan	10 MLD	5 MLD	Gardening purpose

C. *Necessity of the Project*

Gandhinagar city had a UGD (Underground Drainage System) system since 1970. As per CPHEEO Manual design period of sewerage system is 30 years. The laid network is very old. Drainage line has crossed its age limit (more than 40 years). The City requires replacement of Sewerage System for-

- Proper sewage disposal and management
- For better hygienic condition
- For better development of area
- Economic design and planning of sewer

Even if the Expenditure on operation and maintenance of sewerage network is 10 times more than the revenue generated from the sewerage system. Chart shows last 5 years comparison between Expenditure and Revenue.

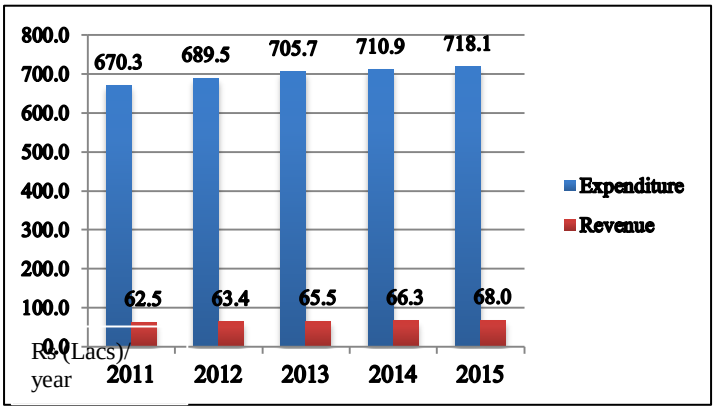

Figure 3. Chart of Comparison of Expenditure and Revenue

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, existing network, invert level of pipe at manhole, land topography, natural barrier, existing and proposed land use, tentatively proposed site for sewage treatment plant and the outfalls etc. 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 Gandhinagar city is divided into two zones.

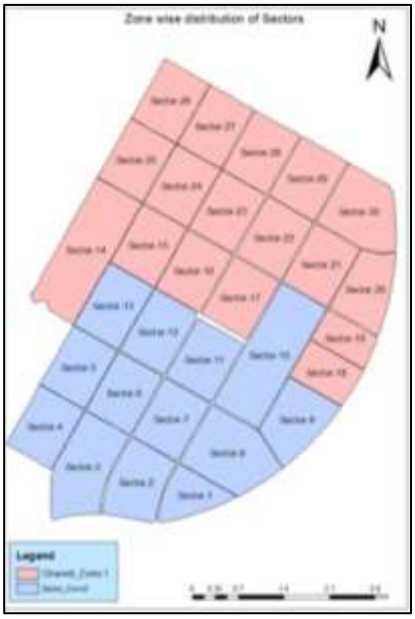

Figure 4. Zone wise Distribution of Sectors

IV. MATERIALS AND METHODS

A. *Data Collection*

For design a Sewer network of Gandhinagar city, the following data were obtained from Capital Project Gandhinagar and Census Bhavan, Gandhinagar.

[1] Collection of the population of last 5 decades of Gandhinagar city.
[2] Collection of the existing water supply detail.
[3] Topographical map of Gandhinagar city.
[4] Road map of Gandhinagar city.
[5] Data of previous existing Sewer network and invert level of existing manhole.

B. *Population Forecast*

Gandhinagar population has grown from 24,055 in 1971 to 2,92,797in 2011. The projected populations for the design horizons for 2016, 2031 and 2046 are 3,79,541, 8,49,111 and 19,78,618 respectively. For design purpose only sector-2 is considered as pilot project. As per the growth of population of Secotr-2 for design purpose population forecasted by Geometrical progression method is considered.

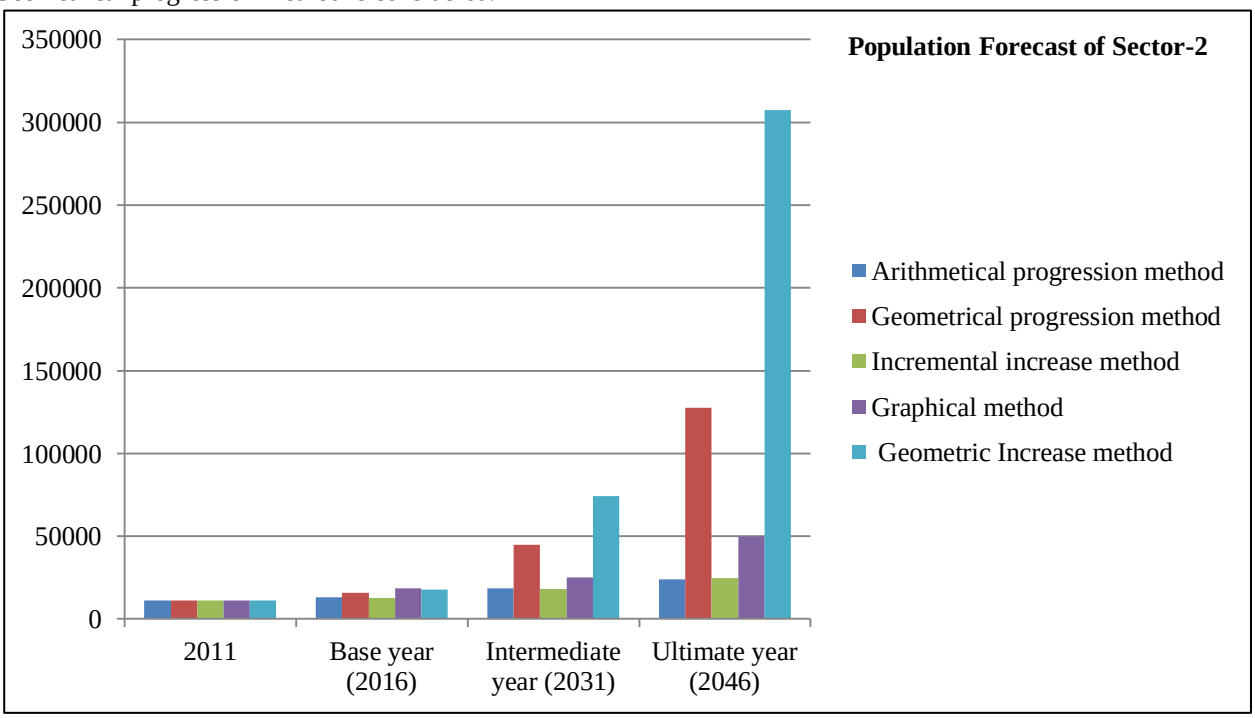

Figure 5. Chart for Population Forecast of Sector-2

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 200 lpcd. As per CPHEEO norms, about 80% of water supply finds its way as wastewater into sewers i.e. 160 lpcd.

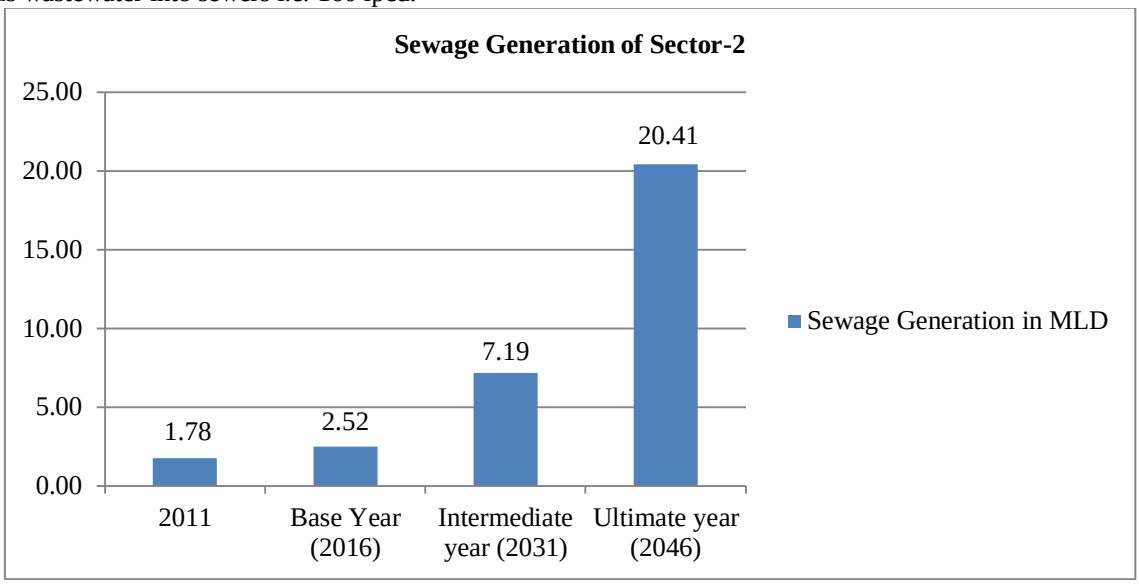

Figure 6. Chart for Sewage Generation of Sector-2

D. *Design Criteria*

The major design criteria adopted for this project are as listed below. The per capita sewage generation is taken as 160 lpcd i.e. 80% of water supply level as suggested by CPHEEO. The minimum diameter of sewer adopted is 150 mm.

Materials used are RCC NP3 pipe. 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 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.

Figure 7 Layout of Network for Sector-2D

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 Arc

Map, 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

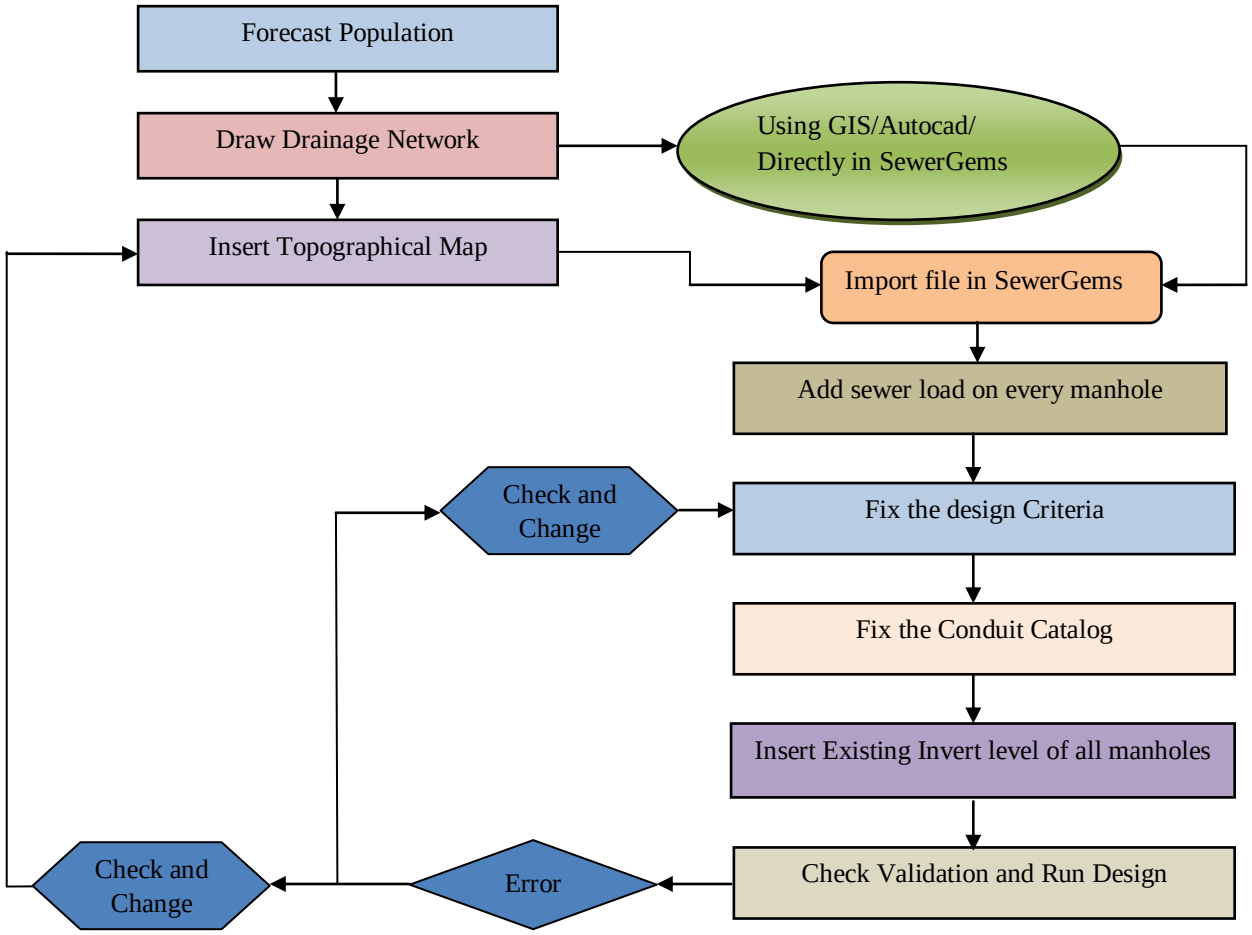

Figure 8. Stepwise Procedure of Design in SewerGEMS Software

C. 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.
- 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.

VI. RESULTS AND DISCUSSIONS

SewerGEMS V8i is an extremely efficient tool for laying out a 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. Sector-2D, Gandhinagar city has designed for the large network of 4376 meters, in that 340 meters of sewer network can be shown Fig.9 and the results are tabulated in table 2.

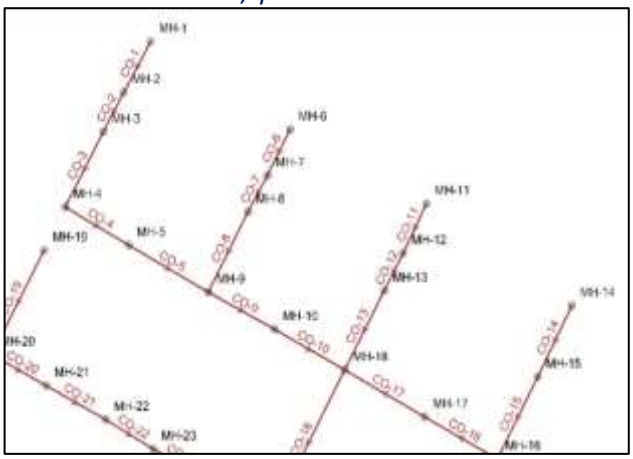

Figure 9. Network Layout in SewerGEMS

Table 2: SewerGEMS V8i results

Label	Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (m/m (H:V))	Section Type	Diameter (mm)	Manning's n	Velocity (m/s)	Depth (Middle) (m)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)
CO-1	MH-1	76.93	MH-2	76.91	16	1000	Circle	150	0.013	0.2	0.04	4.82	17.7
CO-2	MH-2	76.91	MH-3	76.78	12.2	96.686	Circle	150	0.013	0.6	0.04	15.49	12.8
CO-3	MH-3	75.31	MH-4	74.93	23	60	Circle	150	0.013	0.83	0.06	19.66	17.3
CO-4	MH-4	74.93	MH-5	74.81	21.1	182.956	Circle	150	0.013	0.6	0.06	11.26	40.4
CO-5	MH-5	74.76	MH-9	74.63	26.3	198.48	Circle	200	0.013	0.6	0.08	23.28	23.2
CO-6	MH-6	78.16	MH-7	77.93	14	60	Circle	150	0.013	0.49	0.02	19.66	2.9
CO-7	MH-7	77.11	MH-8	76.93	11.3	60	Circle	150	0.013	0.64	0.04	19.66	7.2
CO-8	MH-8	76.93	MH-9	76.72	24.3	118.165	Circle	150	0.013	0.6	0.04	14.01	18.3
CO-9	MH-9	74.63	MH-10	74.55	21.7	284.819	Circle	200	0.013	0.6	0.1	19.43	45.3
CO-10	MH-10	74.55	MH-18	74.47	23.1	297.473	Circle	200	0.013	0.6	0.09	19.02	49.3
CO-11	MH-11	80.93	MH-12	80.91	14.9	1000	Circle	150	0.013	0.2	0.04	4.82	17.7
CO-12	MH-12	80.91	MH-13	80.77	11.5	84.792	Circle	150	0.013	0.6	0.03	16.54	10.3
CO-13	MH-13	79.33	MH-18	78.93	24.1	60	Circle	150	0.013	0.76	0.04	19.66	13
CO-14	MH-14	82.28	MH-15	81.93	21.5	60	Circle	150	0.013	0.55	0.02	19.66	4.3
CO-15	MH-15	81.34	MH-16	80.93	24.9	60	Circle	150	0.013	0.68	0.03	19.66	8.7
CO-16	MH-17	79.93	MH-16	80.32	24	60	Circle	150	0.013	0.79	0.04	19.66	14.5

Here, the yellow colour shows that velocity is not as per CPHEEO manual criteria. This all manholes are starting manhole. As per CPHEEO manual, if we cannot get proper velocity we should provide flushing manhole at particular manhole. Hence, MH-1, 6 and MH-11 are provided as flushing manhole.

VII. CONCLUSIONS

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

- Less time spent to make 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 uncomplicated for the design of sewerage networks. And it accommodating 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.
- Modified representation and information shown both in the layout and longitudinal profile that can be used for any of our projects.
- Concluding drawings produced into a .dwg format which is the most generally accepted file format for engineers.

VIII. ACKNOWLEDGEMENT

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