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Sewerage System Assessment Using Sewer Gems V8i and Autocad Civil 3d

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ABSTRACT: *The paper is about the Assessment of Sewerage system using softwares like SewerGEMS V8i and AutoCAD Civil 3D. Within this study we will be doing a comparative assessment of the sewerage network that we can provide for the present towns and cities that are lacking a proper sewerage systems. We will be using SewerGEMS V8i and AUtoCAD Civil 3D for the analysis purposes. AutoCAD Civil 3D is a better suited software for the purpose of analyzing the topography in a 3D model, it helps to analyze the terrain of any particular area. It includes various commands like creating surfaces, profiles, Cross sections, 3D networks and many more. On the other hand, we will use SewerGEMS V8i for the hydraulic modelling of network in synchroniaztion with the topography achieved from AutoCAD Civil 3D. Furthermore, in this study we will be giving a comparison on the Sewage treatment technologies which are suitable as per the requirement of area, the demand of sewer generated and mostly considering the economical aspect.*

KEYWORDS–*AutoCAD, Sewerage system, SewerGEMS V8i, Sewage Treatment, Terrain*

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I. INTRODUCTION

Talking about the present conditions of the sewer networks and the sewerage system that we see in our day to day life in our localities and the semi-urban areas, we have observed that the condition of the surrounding after laying of these networks has not improved yet. Some areas even big cities are still having old systems most of them are combined sewers which are still in use but with the growing population and also the storm floods they are getting choked and flooded and also affecting the related areas. Because of these conditions we see an urgent need to analyse and study the problems and based on our observation a perfect sewerage system should be designed which will be technically sufficient to cater these problems. All these factors are the real motivation behind our study and we will be adopting advanced methodology to make our study more and more effective. Advanced hydraulic modelling and terrain or topographical analysis using some modern and efficient softwares like SewerGEMS V8i and AutoCAD Civil 3D are one of the major components of our study which will result in an easy working and more effective results.

1.1 Aim of the Study

- Description of software.
- Selection of best suited methods and technologies based on prescribed parameters as per Indian standards.
- Preparation of layouts of the network system.
- Hydraulic Modelling of the proposed network.

II. SOFTWARE DESCRIPTION

2.1 SewerGEMS V8i

Bentley SewerGEMS V8i is the first and only fully-dynamic. It is a multi-platform (GIS, CAD, and Stand-Alone) based sanitary and combined sewer modelling solution. With the help of SewerGEMS V8i, we can analyze all sanitary and combined sewer system elements in one package and we also have the option of performing the analyses with the SWMM algorithm or our own implicit solution of the full Saint Venant equations.

Talking about the work space, SewerGEMS V8i has four different modes for working whichare as follows:

a. Stand-Alone Editor
b. Microstation Editor
c. ArcGIS Mode
d. AutoCAD Mode

2.2 AutoCAD Civil 3D

AutoCAD Civil 3D is a Civil Engineering design and documentation software which is managed and modified by Autodesk. It supports Building Information Modelling (BIM) workflows which is very helpful with the present civil engineering works and studies.

Civil infrastructure project workflows, such as roads and highways, land development, rail, airports and water can be focused on to be optimized to the level of most accuracy, Civil 3D helps civil infrastructure project teams improve delivery, maintain more consistent data and processes, and respond faster to project changes. Civil 3D helps organizations streamline time-consuming tasks such as intersections, roundabout and corridor design, parcel layout, pipes and grading with specific tools and customizable design standards.

III. PREPARING LAYOUT

For the purpose of layout preparation we can analyse the surface data of any projected area through Civil 3D, it has various options to look into the terrain or topography of the projected area based on the relevant data. The first process is to create a surface from the data obtained or collected after survey. In AutoCAD Civil 3D surface can be created from data which are like points, lines, texts, blocks, 3D face and poly face. After creating surface we can analyse the terrain through various style options present in Civil 3D which are surface triangulations, elevation based colour coding, slopes, slope arrows, directions and many more. One of the examples of these options can be seen below:

***Fig 1**. Surface presentation*

The above image shows represents a particular area based on the differences in elevations which are assigned as per colour codings, in the above image from yellow to dark blue the elevation increases which helps us to determine the peak points and the lowest points in any area. For preparing a layout this type of analysis reduces time for selecting best suited path for any gravity based network. The surface can be exported to LANDXML format so that it can be used in various modelling software like SewerGEMS V8i.

With AutoCAD we can prepare the pipe network in the same software and then we can export it to .dxf format so that it can be imported to SewerGEMS V8i and we can do the hydraulic modelling without getting through the difficulty of finding path and laying the network manually in SewerGEMS. With both the ground levels from the surface file and the pipe network we don’t have to assign the junctions locations and levels manually.

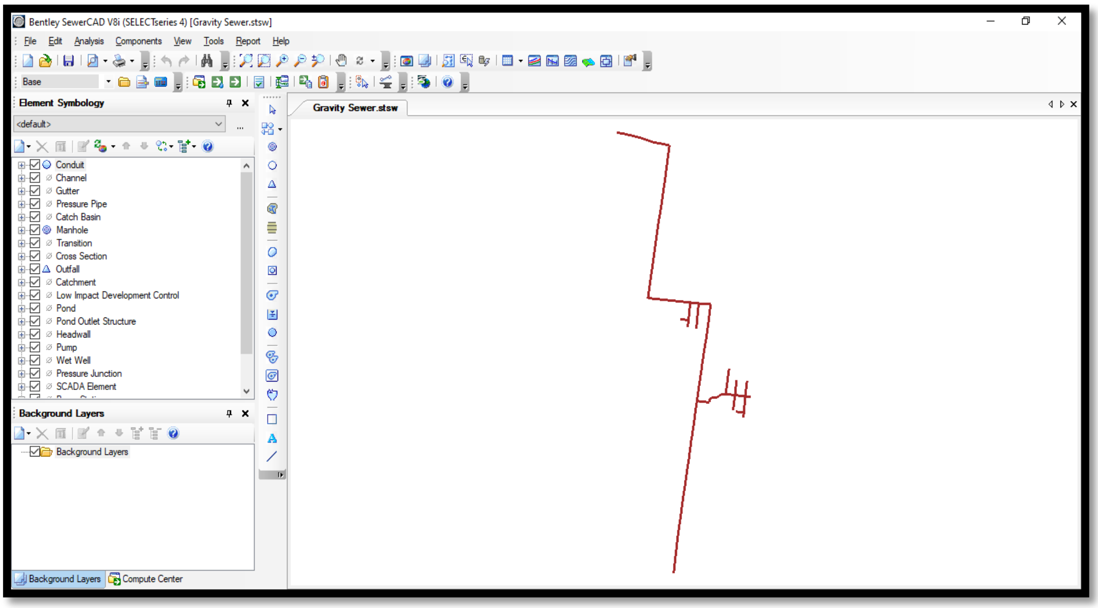

***Fig 2.** Sample pipe network in SewerGEMS V8i*

IV. HYDRAULIC ANALYSIS

After preparing the layout we can start with the hydraulic analysis of the proposed pipe network. First of all for hydraulic analysis we need the demand of the sewer generated by the projected area and for that purpose we need the projected population of the respective area for the design year.

4.1 Population Forecasting

We can calculate the population of the area for a particular year through various formulas which are as follows:

a. Arithmetic Progression Method
b. Geometric Progression Method
c. Incremental Increase Method
d. Decrease rate of growth Method or Decreasing rate Method

4.2 Hydraulic Demand

After calculating the population now we need to calculate the demand for which the pipe network will be designed. As per CPHEEO Manual 80% of the water supply may be expected to reach the sewers unless there is data available to the contrary. The rate of water supply has been adopted as per the norms of CPHEEO manual as 135 LPCD at consumer end throughout the whole design period. 80% of the water supply has been considered as sewage flow into the sewerage system which works out 108 LPCD. This data is only for the residential population for other category of population the rate of supply varies and should be adopted accordingly as mentioned in the CPHEEO Manual.

In the hydraulic design of sewers, an allowance for infiltration for the project area would be considered as below:

SL	Description	Minimum	Maximum
1	Litres/ha/day	5000	50000
2	Litres/km/day	500	5000
3	Litres/day/manhole	250	500

Table 1. Details of Ground water Infiltration as per CPHEEO

For Flow quantification and design purpose, infiltration @10% of average Dry weather flow has been considered as per latest CPHEEO Guidelines.

4.2.1 Peak Factor

Peak factor for sewerage system is based on contributing population for domestic sewage as per CPHEEO sewerage manual, 2013. Peak factor for design of sewerage system in project area as per Manual is given in following Table

SL	Contributing Population	Peak Factor
1	Upto 20,000	3.00
2	20,000 to 50,000	2.50
3	50,000 to 7,50,000	2.25
4	Above 7,50,000	2.00

Table 2. Recommended Peak Factors for Estimation of Domestic Sewage

4.2.2 Coefficient of Roughness

The coefficient of roughness is based on type of sewer material proposed for the sewage conveyance. The coefficient of roughness 'n' for Cement concrete pipe as prescribed in CPHEEO sewerage manual, 2013 as 0.013.

Note: Values of n may be taken as 0.015 for unlined metallic pipes and 0.011 for plastic and other smooth pipes.

Source: CPHEEO

4.2.3 Design Capacity of Sewer

Sewers shall be designed to carry estimated peak flows generated in the design year and would be designed 80% full at ultimate peak flow. This is to ensure proper ventilation and prevent septicity of sewage.

4.2.4 Self-Cleansing Velocity

To disable the deposition of suspended solids, self-cleansing velocities shall be ensured in the sewer network design. Estimated self-cleansing velocity using Shield's formula shall be considered in the design of sewers.

$V= (1/n) \times R^{1/6} \{K_S (S_S – 1) \times d_p\}^{1/2}$

Where,

S_S Specific gravity of particle

d_p particle size in mm

K_S dimensionless constant

R Hydraulic mean radius in m

n Manning's Coefficient

Considering typical values of particle size and specific gravity, minimum partial flow velocities is considered at present peak flows and at design peak flows. The maximum velocity shall be considered in order to prevent scouring. The following Table shows the minimum and maximum velocities in sewer as per CPHEEO Manual (latest edition).

Sr. No.	Criteria	Velocity (m/s)
1	Minimum velocity at initial peak flow	0.6
2	Minimum velocity at ultimate peak flow	0.8
3	Maximum velocity	2.5

Table 3. Maximum and Minimum velocity in sewer

4.2.5 Design Formula

Manning's formula would be adopted as per CPHEEO Manual, Nov 2013 for design of gravity sewers and explained as under-

$$Q_f = V_f \times A$$
$$V_f = 1/N \times R^{2/3} \times S^{1/2}$$

Where,

Q_f = Flow rate (in m3/sec)

A = Cross sectional area of pipe (sq. m.)

V_f = Velocity (in m/s)

N = Manning's roughness coefficient

R = Hydraulic radius (m).

S = Slope of energy gradient

Based on the aforementioned criteria we can proceed with the hydraulic modelling, these standard and criteria are basically used in India for Hydraulic modelling.

In SewerGEMS V8i we just have to set the values in the "Default Design Condstraints" and classify and enter the load in the "Unit Sanitary (Dry Weather) Loads".

Label	Start Node	Stop Node	Invert (Start) (m)	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (m/m)	Section Type	Diameter (mm)	Manning's n	Flow (L/s)	Velocity (m/s)	Depth (Middle) (m)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)
2	2	3	197.86	197.71	30	0.005	Circle	150	0.013	5.77	0.33	0.15	10.77	53.5
1	1	3	197.99	197.87	24	0.005	Circle	150	0.013	5.77	0.33	0.15	10.77	53.5
3	3	4	197.71	197.56	30	0.005	Circle	150	0.013	16.95	0.96	0.15	10.77	157.4
4	4	65	197.56	197.26	30	0.01	Circle	150	0.013	21.33	1.21	0.15	15.23	140.1
31	31	32	199.16	199.01	30	0.005	Circle	150	0.013	5.77	0.33	0.15	10.76	53.6
32	32	33	199.01	198.86	30	0.005	Circle	200	0.013	11.53	0.37	0.2	23.21	49.7
33	33	34	198.86	198.71	30	0.005	Circle	150	0.013	16.95	0.96	0.15	10.77	157.4
34	34	35	198.71	198.56	30	0.005	Circle	150	0.013	21.33	1.21	0.15	10.76	198.3
35	35	36	198.56	198.46	30	0.003	Circle	150	0.013	25.5	1.44	0.15	8.79	290.2
36	36	37	198.46	198.36	30	0.003	Circle	150	0.013	29.51	1.67	0.15	8.79	335.8
37	37	38	198.36	198.26	30	0.003	Circle	150	0.013	33.38	1.89	0.15	8.79	379.8
38	38	39	198.26	198.16	30	0.003	Circle	150	0.013	37.15	2.1	0.15	8.79	422.5
39	39	40	198.11	198.04	30	0.002	Circle	200	0.013	40.82	1.3	0.2	15.84	257.7
40	40	41	198.04	197.97	30	0.002	Circle	200	0.013	44.41	1.41	0.2	15.84	280.4
41	41	42	197.97	197.9	30	0.002	Circle	200	0.013	47.92	1.53	0.2	15.85	302.4
42	42	43	197.9	197.83	30	0.002	Circle	200	0.013	51.38	1.64	0.2	15.84	324.4
43	43	44	197.83	197.76	30	0.002	Circle	200	0.013	54.78	1.74	0.2	15.83	346
44	44	45	197.71	197.64	30	0.002	Circle	250	0.013	58.12	1.18	0.25	28.75	202.2
45	45	46	197.64	197.58	30	0.002	Circle	250	0.013	61.42	1.25	0.25	26.59	230.9

Table 4. Sample Pipe Design output obtained from SewerGEMS V8i

4.3 Sewage Treatment Technology

There are a number of treatment technologies that are applied for sewage treatment in India andelsewhere. The technologies that have been used are mostly biological and have their own merits anddemerits. In order to arrive at the best feasible sewage treatment option from a techno-economicpoint of view, broadly following criteria has been adopted for selection of the sewage treatmentoptions for evaluation.

- Activated Sludge Process (ASP)
- Sequential Batch Reactor (SBR)
- Moving Bed Biofilm Reactor (MBBR)
- Membrane Bioreactor (MBR)

4.3.1 Activate Sludge Process

The activated sludge process is a type of wastewater treatment process for treating sewage or industrial wastewaters using aeration and suspended growth process. It requires large power for aeration, return sludge pumping etc. the replacement time required is 15 years. The power cost is high as it requires uninterrupted power supply. It requires skilled labours and also the maintenance cost is high. Though the process is relatively simple and it proves to be reliable with proper operation and control. The efficiency achieved in this process is about 85-95%, it requires 0.17-0.25 hectare per MLD space.

4.3.2 Sequential Batch Reactor

The SBR is also an aerobic based and suspended growth process, it is a modified form of ASP. It requires lower cost than the ASP, have medium power cost. It requires higher skill to control. The maintenance cost is medium and has more automated features. The cycle time control adds some operational complexity to the process. It proves to be reliable with proper operation and control. The efficiency achieved through SBR is 95-98%. The space requirement for SBR setup is 0.09-0.125 hectares per MLD.

4.3.3 Moving Bed Biofilm Reactor

The MBBR is a type of wastewater treatment process for treating wastewater using aeration. It is a fixed growth process. The capital cost is high as compared to ASP & SBR, including the cost of secondary clarifier as well as the MBBR media. The media has to be replaced after 5-7 years. The power cost is medium, it can be simply operated as the process is relatively simple. The maintenance cost is also medium. The efficiency achieved in MBBR process is 95-98% and the space requirement is 0.08-0.11 hectares per MLD.

4.3.4 Membrane Bioreactor

MBR is an aerobic treatment process for treating wastewater. It is a suspended growth process and uses membrane technology to treat the wastewater. The capital cost is high which includes the membrane cost. The membrane is to be replaced after 5-7 years. The power cost is high and it requires skilled persons. The maintenance is more automated. The MBR monitoring, scouring and maintenance cleaning adds some complexity to the entire process. It is highly reliable as the effluent quality is much better as compared to the previous mentioned technologies. The efficiency achieved through MBR is 95-98% and the area requirement is very less which is 0.03 hectares per MLD.

V. CONCLUSION

Based on our study we can say that SewerGEMS V8i is a very convenient software for Hydraulic modelling of wastewater networks. The software is fully dynamic and the automated function makes it more convenient. Along with this AutoCAD Civil 3D is a very efficient software for topographical analysis and the network route assessment.

Also, based on our comparative assessment of the treatment technologies we can say that the selection of the treatment process is completely based on the demand generated, reuse of effluent and the space availability for the setup.

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