ANALYSIS AND DESIGN OF SEWER NETWORK USING SewerGEMS

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Abstract: Traditional design of sewer network is very time consuming and cumbersome and require lot of efforts to do the analysis of the flow of entire system. Any modification in the design parameter will lead to the revision of all the analysis from the scratch. There are many numerical models available to do the flow analysis of sewer network, which are very efficient from the point of view of time consumption, modification, representation, estimation and accuracy. Sewer system is very complicated to design as there are many essential parameters/checks are to be satisfied simultaneously i.e slope, velocity, invert level of pipes and manholes, excavation limitation, maintenance and costing of the project. Of all these available software, "SewerGEMS" is very popular amongst all because the unique benefits it provides. SewerGEMS is very easy-to-use software for engineers to analyze and design sewer systems, using built-in hydraulic tools. In addition, it is compatible with AUTOCAD and Geographical Information system (GIS) tools. At the end, the software provides design parameters such as invert levels and diameter of the pipeline as well as the invert levels of manholes. Current research aims at designing a sewer collection network using "SewerGEMS".

IndexTerms - **SewerGEMS, Sewer network design, AUTOCAD, GIS**

I. Introduction

Sewer network is designed for the transportation of domestic or industrial waste water from source point to the treatment plant or disposal site. Now a day, computerized numerical models relieve engineers of tiresome, iterative calculations, which allows them to focus on design decisions. Numerical models can account for much more of the complexity of real world systems than manual calculations. Application of numerical models has proved to increase the confidence that the design will function properly when it is installed. The ease and speed of modeling has provided the engineers the ability to explore more options under a variety of conditions, resulting in a more cost-effective and robust design. Finally, models are integrated with computer aided drafting (CAD) and geographic information systems (GIS) softwares which facilitate the production of construction drawings and making better use of the available data.

II. INFORMATION ABOUT THE SOFTWARE

SewerGEMS provides a straightforward and very easy environment for engineers to analyze, design, and operate sanitary or combined conveyance sewer systems using built-in hydraulic and hydrology tools.

SewerGEMS offers superior Interoperability. It also works well within four different well known platforms so that a single, shared project data source can be assessed within any of the platform.

These platforms are:
• Windows stand alone for ease of use, accessibility, and performance
• ArcGIS for GIS integration and thematic mapping
• MicroStation for bridging geospatial planning and engineering design environments
• AutoCAD for convenient CAD layout and drafting

With the help of the LoadBuilder module, modelers can allocate sewer loads based on a different GIS-based sources such as customer water use billing data, flow measurement data of particular area as well as polygons with known population or land use. Sewer loading can also be carried out by using user-defined hydrographs, pattern-based loads and unit loads. Engineers can also access and customize the comprehensive unit load engineering library with numerous typical unit loads based on population, area, count, and discharge.

SewerGEMS also allows users to input and save an unlimited number of flow patterns, to accurately model flow changes over the course of a day.

With the help of SewerGEMS, users can configure, evaluate, visualize, and compare an unlimited number of scenarios within a single file. It would help the Engineers for better decision-making support.

Modeling of Hydrogen sulfide formation is also possible in SewerGEMS. This would be useful to know the risk of pipe damage from H_2S formation, associated odor, and safety of the workers.

III. SEWAGE NETWORK DESIGN

Following steps have been followed for the design of gravity sewer systems.

1. To identify the area(s) where sewage collection network is desired.
2. To get familiar with current prevailing regulatory codes, design guidelines and to set system design criteria.
3. To collect geologic, geographic, and topographic data.
4. To collect available information such as roads, population, industry, other utilities and community planning.
5. To carry out reconnaissance survey at sites that potentially conflict with other services.
6. To identify the natural drainages, streets, and existing or planned wastewater

inflow points at the boundaries of the area to be served.

7. To prepare/design the horizontal layout of the sewer line, manholes and possible pumping station locations. To prepare alternate layouts for feasibility checks in any of the platform compatible with SewerGEMS. This followed by importing AutoCAD file (*.dxf) file and GIS shapefile (*.shp) using model builder and Trex tool respectively in the SewerGEMS.

8. To carry out population forecasting and to allocate it to contributing manholes.

9. To Select the pipe sizes and slopes as well as to perform the hydraulic design of the system. Revise selections until the design criteria are met.

10. To Carefully review all designs, along with assumptions and alternates.

11. To modify the design or to develop alternate designs, or even alternate layouts. This will bring the designer back to the appropriate earlier step.

IV. METHODOLOGY

A. SewerGEMS is an extremely efficient tool for laying out a storm or sanitary sewer network. It is easy to prepare a schematic or scaled model. SewerGEMS takes care of the link-node connectivity automatically. While generating the sewer network, one should not worry for assigning the labels to pipes and nodes. The software assigns labels automatically. If a scanned schematic drawing is imported and digitized then pipe lengths are entered manually in the user defined length field. Pipe lengths are automatically calculated from the position of the pipes, bends and start and stop nodes in the drawing pane if the drawing is scaled. For the purposes of this research, the network is created in AutoCAD in .dxf file format and imported in SewerGEMS using model builder as shown in Fig 1.

B. The point feature shapeflie of all the node points containing ground elevation data was prepared in GIS and same file as imported in SewerGEMS using Trex tool. This allowed SewerGEMS to take care of the link-node connectivity automatically and to assign respective node elevation and length to all the link pipes. Using network navigation tool, network can be traced for any error such as loops, dead ends, connected and disconnected pipes to outfall, orphan nodes etc., and such errors should be eliminated prior to run the model. The node and Conduit data must have been assigned prior to run the model as shown in fig 3.

C. Population forecasting was carried out by three different methods i.e arithmetic increase method, incremental increase method and geometric increase method. Final population was taken as the average of the answers of the above three methods. This population was assigned to each manhole in such a way that the summation of all the individual population data becomes equal to the total population forecasted. For the sake of simplicity, the total length of the pipe network has been divided the total population and the same was assigned to the individual link as per its length.

D. To calculate the flow, 135 LPCD (liters per capita per Day) water supply to individual has been considered. It is assumed that 80% of the total supplied water is getting converted into the sewage. Hence, 108 LPCD discharge is considered for analysis and design of network. The peak factor or the ratio of maximum to average flow depends upon contributory population as given in Table 3.2 of CPHEEO manual, which has been shown below in Table 1.

Table No.1 Peak factor for Contributory Population

Contributory Population	Peak Factor
up to 20,000	3.00
Above 20,001 to 50,000	2.50
Above 50,001 to 7,50,000	2.25
Above 7,50,001	2.0

E. Various design constraints like velocity, top cover and slope in accordance with CPHEEO manual have been adopted while analyzing and designing the network as shown in fig 4. below.
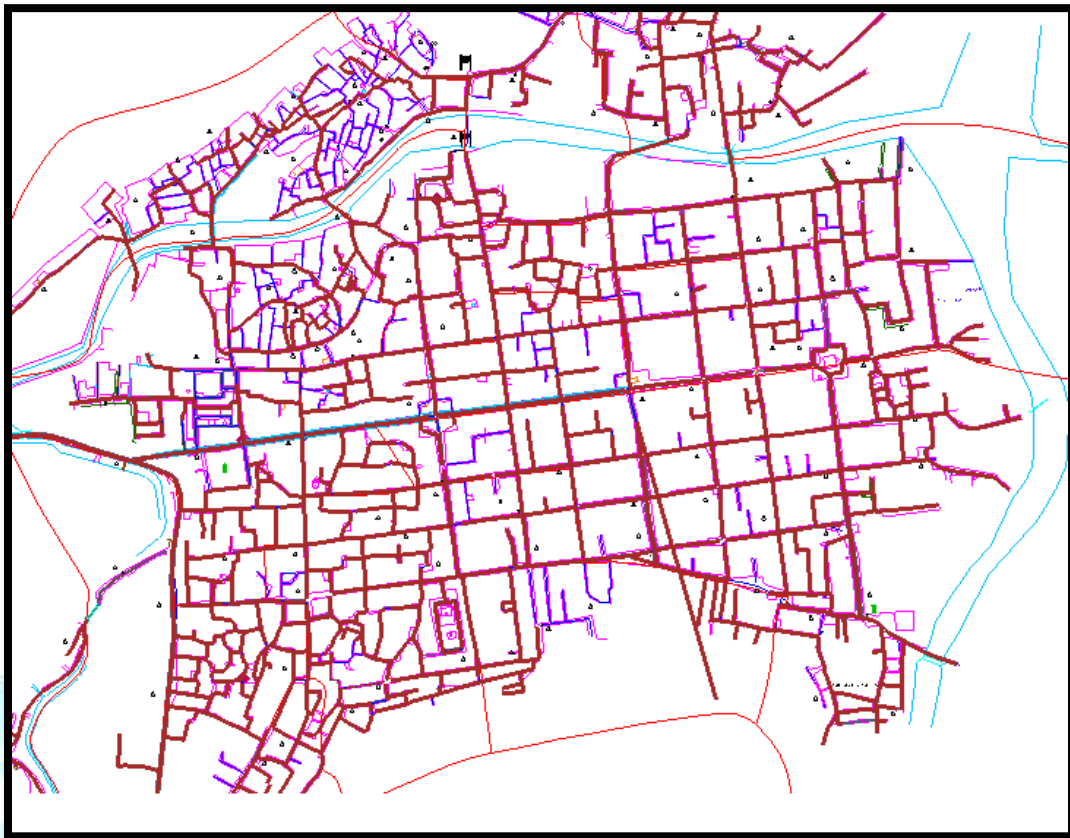
Fig. 1 Imported Sewer Network AutoCAD file in SewerGEMS

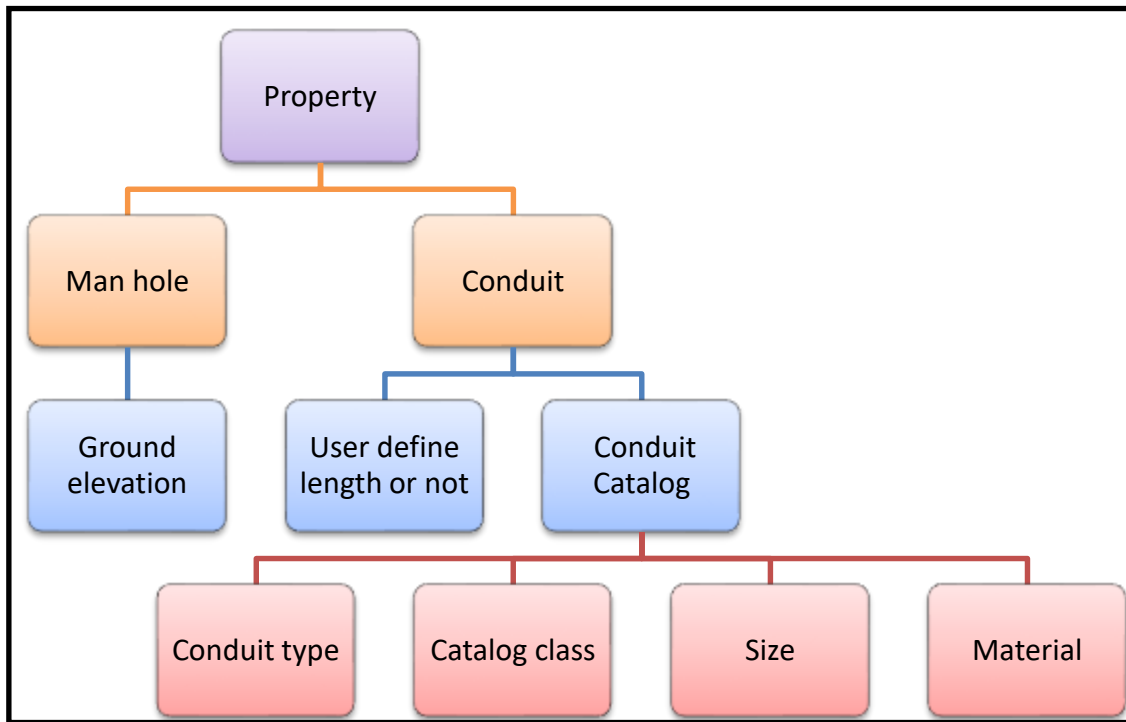

Fig 2 Ground Elevation feature file

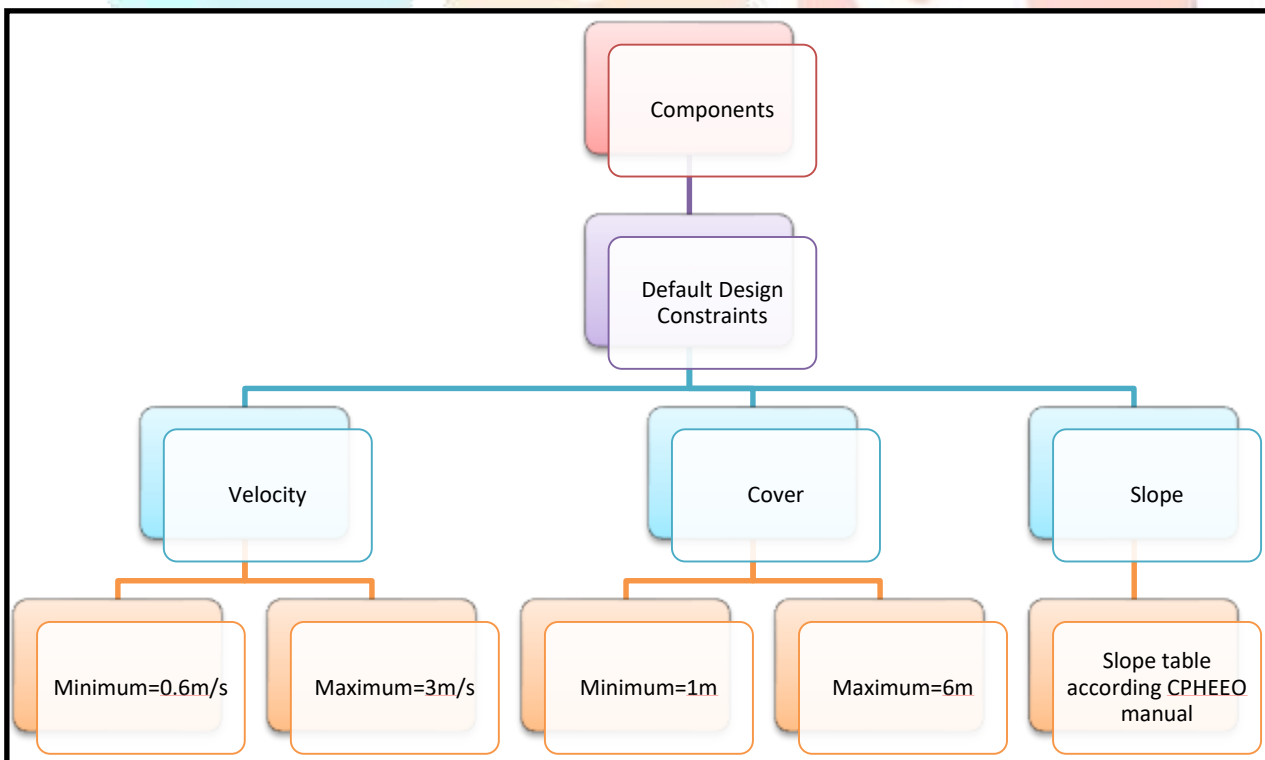Fig. 3 Attributes assignment to the conduit and manhole features

Fig 4. Design constraints

F. Last step is to run the model and to check any ambiguity with already set design constraints. The errors are solved by modifying the network details. At the end, pipe diameters, manhole depths, covers, velocities, slopes, flow, Hydraulic Gradients and invert levels

are obtained as output. These outputs are obtained in the form of a table and represented in the longitudinal section drawings as shown in fig 5. and fig 6. as shown below.

| Start Node	Stop Node	Length (Scaled) (m)	Cover (Start) (m)	Diameter (mm)	Manning's n	Slope (Calculated) (1/S)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Invert (Start) (m)	Invert (Stop) (m)
MH-27	MH-43	11.4	14.59	600.0	0.013	1,000.000	280.41	277.85	265.22	265.21
MH-36	O-4	16.1	13.55	375.0	0.013	597.030	269.96	269.91	256.03	256.01
MH-36	MH-39	49.0	13.55	375.0	0.013	597.030	269.96	269.82	256.03	256.11
MH-45	MH-39	78.8	13.14	375.0	0.013	597.030	269.76	269.82	256.25	256.11
MH-29	MH-27	25.0	12.80	600.0	0.013	1,000.000	278.65	280.41	265.24	265.22
MH-30	MH-43	26.4	12.80	600.0	0.013	1,000.000	278.58	277.85	265.18	265.21
MH-32	MH-64	22.9	12.58	600.0	0.013	1,000.000	278.61	277.21	265.43	265.45
MH-488	MH-495	49.0	12.57	250.0	0.013	360.000	256.14	256.17	243.31	243.45
MH-54	MH-45	23.1	12.57	375.0	0.013	597.030	269.23	269.76	256.28	256.25
MH-352	MH-346	37.6	12.55	250.0	0.013	360.000	257.05	257.14	244.25	244.35
MH-346	MH-330	68.6	12.54	250.0	0.013	360.000	257.14	257.31	244.35	244.54
MH-34	MH-32	7.8	12.54	600.0	0.013	1,000.000	278.56	278.61	265.42	265.43
MH-434	MH-491	85.9	12.52	250.0	0.013	360.000	256.54	256.53	243.77	244.01
MH-330	MH-349	116.4	12.51	250.0	0.013	360.000	257.31	257.44	244.54	244.86
MH-35	MH-34	14.8	12.51	600.0	0.013	1,000.000	278.52	278.56	265.41	265.42
MH-46	MH-28	15.9	12.49	200.0	0.013	250.000	294.20	296.66	281.51	281.57
MH-495	MH-487	80.5	12.47	250.0	0.013	360.000	256.17	256.36	243.45	243.67
MH-487	MH-434	33.3	12.43	250.0	0.013	360.000	256.36	256.54	243.67	243.77
MH-521	MH-523	46.1	12.37	300.0	0.013	450.000	255.61	255.66	242.94	243.04
MH-521	MH-668	246.8	12.37	300.0	0.013	450.000	255.61	254.24	242.94	242.39
MH-516	MH-488	43.5	12.35	250.0	0.013	360.000	255.80	256.14	243.19	243.31
MH-349	MH-364	104.3	12.33	250.0	0.013	360.000	257.44	257.55	244.86	245.15
MH-523	MH-516	36.5	12.32	250.0	0.013	360.000	255.66	255.80	243.09	243.19

Fig 5 Flex table
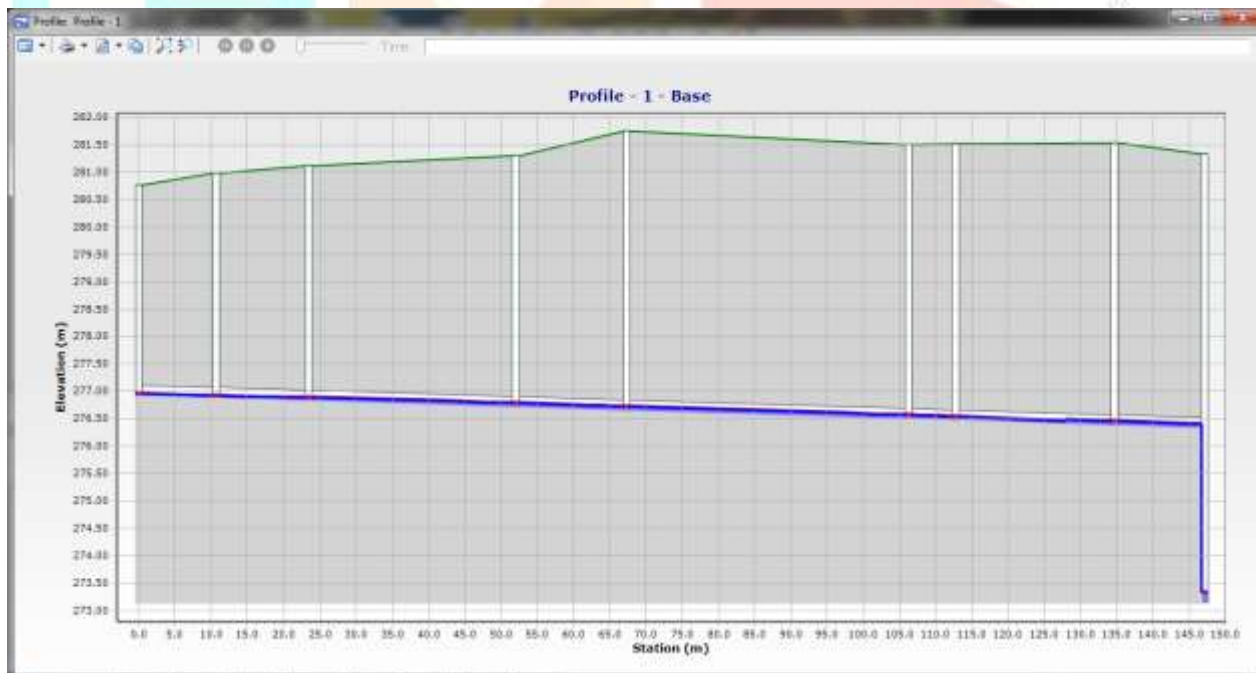
Fig 6 Longitudinal Section

V. CONCLUSION

The town road network layout was drawn in AutoCAD and ground elevation feature was generated in GIS platform and imported in SewerGEMS. Necessary corrections are made in the network to eleminate errors like loop, dead end, orphan nodes etc., using Network navigation tool of SewerGEMS. It was followed by assigning necessary details like population, discharge, peak factor and other design constraints like velocity, cover and slope. Then after, model was run and output was compared to the design constraints. The network and input data are changed till the desired design constraints are obtained.

Following observations are made after using SewerGEMS for sewer network design:

- SewerGEMS provides the lowest diameter to allow the assigned flow as the output results. This results in the economical solution of the project.
- SewerGEMS provides a map showing details such as pipe, velocity, elevations and flow right on it as the output results.
- The minimum and maximum velocity condition is satisfied for each link.
- The layout and longitudinal section drawings are easily generated with all the necessary details on it. This helps in generating the necessary project drawings in no time. The drawings can be exported in many familiar formats like dwg, dxf, pdf etc., which can be shared and modified very easily as and when required during the project duration.
- SewerGEMS is easy-to-use and proves to be very efficient for large sewer network.

REFERENCES

1. CPHEEO (2013) ―Manual on Sewer and Sewerage System‖, Ministry of Urban Development, Government of India, New Delhi
2. D. Ram Mohan Rao., Zameer Ahmed., Dr.K.Ram Mohan Reddy and Dr. Ellam Raj, (2013), Selection of Drainage Network Using Raster GIS – A Case Study, nternational Journal of Engineering Science Invention, Vol 2, PP.35-40.
3. Eliman.A.A, and Charalambous, C. (1990), ―Heuristic design of sewer network‖, ASCE Journal of Environmental Engineering, vol-116(6), PP 1181-1199
4. Fryd, O., Dam, T., Jensen, M.B, (2012), ―A planning framework for sustainable urban drainage systems‖, Water Policy 2012, 14, 865–886.
5. Garg, S.K., 2012, ―Sewage disposal and air pollution engineering‖, Khanna publishers, New Delhi.
6. Modak.P.M, and Dhoondia.J, (1991), ―User Instruction for SEWER Version 3.0‖, UNDP/WORLD BANK ASIA water supply and sanitation sector Development project.
7. Murugesh Katti, Dr. B. M. Krishna and Dr. B. Manoj Kumar, (2015), ―Design of Sewer Network for Vijayapur city using SEWER Version 3.0 software, IJSRD ,Vol. 3, Issue 04, 2015 | ISSN (online): 2321-0613.
8. Mailhot, A., Duchesne, S, (2010), ―Design criteria of urban drainage infrastructures under climate change,‖ J. Water Resour. Plan. Manag. Asce 2010, 136, 201–208.
9. NAGOSHE S. R., RAI, R. K., and KADAM, K.N, (2014),‖ Optimization Of Sewerage Network By Dynamic Programming. Proceedings of 3rd IRF International Conference, Goa, India, ISBN: 978-93-84209-15-5.
10. Nicoleta SCARLAT, Severin CAZANESCU and Simona MALUREANU, (2009), ―Modeling of Sewage Networks with Computer Aided Design Software‖, Bulletin UASVM Agriculture, 66 (2), Print ISSN 1843-5246; Electronic ISSN 1843-5386.
11. Rangwala, S. C., (2007), Water Supply and Sanitary Engineering, Charotar Publishing House, Anand India.
12. Rai, R. K., Nagoshe, S. R., and Sadigale, S. G.(2014). ―Optimal Design of Sewerage Network‖, National Conference on Emerging Trends In Engineering, Technology and Architecture.
13. Swamee, P. K. (2001). ―Design of Sewer Line‖. Journal Environmental Engineering, (127), 776-78.