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# Sanitary Gravity Sewer Design using Sewer GEMS Software Connect Edition for Utsav Vihar, Karala

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***Abstract*: *The paper presents modeling, design and analysis of sewage network of Utsav Vihar by means of SewerGEMS software which helps in the achievement of project results in a shorter period of time in an effective way and at reasonable prices. In the present study the sewerage was designed for Utsav Vihar area in North – West Delhi District. SewerGEMS software eases the designing for engineers because of unique features to offer a fully dynamic and multi-platform sanitary and combined sewer modeling solution which otherwise tends to consume a lot of time and energy. The software uses derived equations and theorems for calculating the hydraulic model. It enables engineers to analyze all sanitary and combined sewer networks in a single package. The hydraulic design section includes the calculation and determination of the transit, total flow and hydraulic modeling for network pipes diameters or slopes. The application generates reports, layouts, longitudinal or transverse cross section.***

***Keywords: curvilinear method, Utsav Vihar, SewerGEMS, rainfall estimation, peak flow, sanitary loading.***

## I. INTRODUCTION

Sanitary Sewer Systems have been an important part in any society as they help to keep our environment clean and free from flooding and water borne diseases like malaria, typhoid fever and cholera by safely conveying domestic and industrial sewage which is kind of water waste produced by human beings, to treatment facilities with the help of sanitary pipes of different diameters and material lying under the ground at a specific distance from the earth surface, Sewage or Sewer System is an underground structure made of numerous pipes for means of conveyance of sewages to treatment or disposal sites. Nowadays designing Sewer System for big and small cities is a critical problem that most of the countries are facing as construction of such huge facilities is costly and time consuming and requires huge investment and maintenance cost of its infrastructure, for such high price facilities we require a decent design to increase the efficiency of work and to avoid any kind of unnecessary expenditures.

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Bentley has introduced a software called SewerGEMS as a solution to all above problems to design a cost effective and highly efficient sewer system in a short time.

The SewerGEMS software is one of the most advantageous tools in order to design an economic and cost-effective sewer network which gives the best possible cost and layout of a large network having different pipe diameters by considering the flow in the pipe velocity.

## II. AREA UNDER CONSIDERATION

### A. Area

The area taken for study is Utsav Vihar near Karala village located in North- West Delhi. The total area was found to be 28 hectares and latitude and longitude of 28°44′05.49″N & 77°02′33.95″E respectively.

### B. History

This area does not have a proper sewer system and has an open drain system for flow of domestic sewage which can cause water- borne diseases and smelly odor in the area, The existing system is poorly constructed and not able to carry sewage to outfall properly, thus this area requires a systematic and proper designed sewer for conveyance of sewage generated in the area.

## III. POPULATION AND WATER CONSUMPTION DEMAND

### A. Population Forecast

For determining the population of the area graphical methods have been used.The sewerage network has been designed for a design period till 2031. The population density of North- West Delhi by year 2031 and especially for the Utsav Vihar area was determined.

The method used in this project is the curvilinear method. It involves graphical projection of the past population growth curve, continuing whatever trends the historical data indicates. This method was the most feasible as the population in the area considered does not face any factors which may lead to decline in population growth, which ruled out the usage of any decline curve method[1]. This was the most reliable method to get a realistic forecast where the graph is plotted as Population vs. Year. The population of North- West Delhi District in the year 1991, 2001, 2011 were 1,208,975, 2,267,023 & 2,731,929 according to the Census of India [6 ][7].

The following curve was plotted and the value corresponding to the year 2031 was nearly 65,00,000. Using the population density the estimated population of Utsav Vihar by 2031 is 7,392.

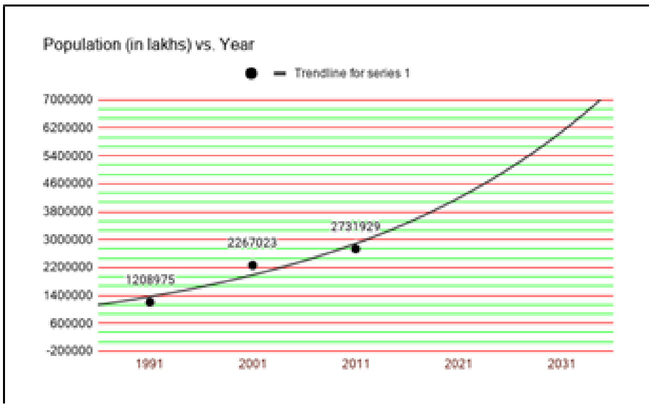


**Fig. 1. Population (in lakhs) vs. year**

### B. Water Consumption Demand

- Residual Demand- The demand includes all the household water demand like cooking, bathing and washing and the quantity varies according to the climatic conditions and social customs. The total residual demand of Utsav Vihar was found to be 2,072,000 Litres per day.
- Commercial Demand- Commercial building like offices, schools, hotels, shopping malls etc. contribute to commercial demand. Since there is only one school in this area and no other commercial building the water demand of school was found to be 4000 Litres per day.
- Fire Demand- Fire demand may arise due to short circuit or accidental fires. Using Kuichling's formula the fire demand of the area was found to be 12270 Litres per day.
- Infiltration Flow- Sewer water may include some flow due to infiltration of ground water. According to CPHEEO the infiltration flow of the area was estimated to be 178.5 Litres per day [2].
- Taking 40% of residential, commercial and fire demand in accordance to CPHEEO manual, and adding infiltration, the total water consumption of the area is 835490 Litres per day [2].

## IV. CATCHMENT AND RAINFALL ESTIMATION

### A. Catchment and Loadings

The area under consideration was divided into 7 parts for the sake of ease of study as well as determining the sanitary loading in each catchment. The area of Utsav Vihar, Karala is 28 hectares. This has been recorded from Google Earth Pro was precision. The division of area has been shown in the figure below.


**Fig. 2. Division of area into catchments**

Various unitary loadings according to CPHEEO are 45 lcpd(litres per capita per day) for schools and 15 lcpd for open areas [2].A loading column for catchment 3 according to Sanitary Load library of SewerGEMS software has been shown below.

**TABLE- I. Loading column for catchment area 3**

| Type | Number of Houses | Number of residents/units | Unitary Load (L/day) |
|---|---|---|---|
| Average Home | 70 | 280 | 280 |
| Better Home | 6 | 36 | 310 |
| Store | 4 | 4 | 2000 |
| School (small) | 1 | 100 | 60 |

### B. Runoff Estimation

Rational Method is the simplest method to calculate the peak discharge from drainage basin runoff and most urban storm drainage systems are designed based on this method. The Rational equation is as given below:

$$Q = 10CIA \tag{1}$$

Where Q= Peak Discharge ($m^3$/hr), I= Rainfall Intensity (mm/hr), C= Rational Method Runoff Coefficient, A= Drainage Area (ha) [3].

Rainfall Intensity (I) was found from Intensity-Duration- Frequency Curve. A log- log graph between rainfall intensity (i) (obtained from monthly rainfall data) and time(t) was plotted according to the following equation [4].

$$\log i = \log a - n \log t \tag{2}$$

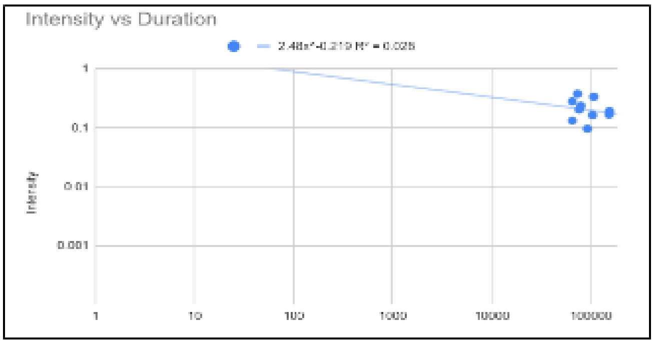


**Fig 3. Log-Log Graph of Intensity vs. Duration**

From the Log-Log graph the values of ‘a’ and ‘n’ were obtained and were respectively 2.48 and 0.219.

### C. IDF Curve

The Intensity-Duration-frequency (IDF) curve was plotted using SewerGEMS feature of entering storm data. The values of ‘a’ and ‘n’ obtained by the Log-Log relationship shown in Fig. 3 were entered and the required IDF curve was obtained. The rainfall intensity to be used for estimation of peak flow was obtained from this curve.

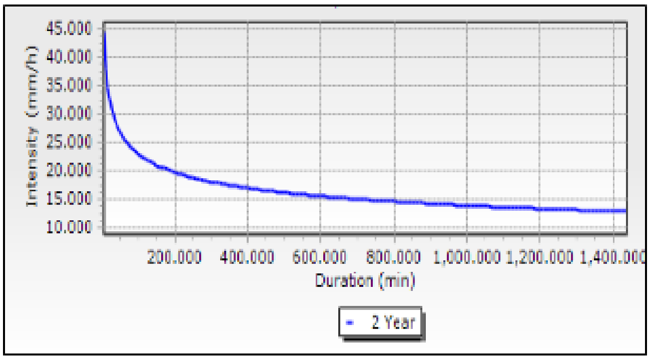


**Fig 4. IDF Curve via SewerGEMS Software**

### D. Peak Flow

The Runoff Coefficient C as mentioned earlier was obtained with the help of the IDF Curve. The percentage of imperviousness ($I_m$) of different area was considered in determining C. The maximum time duration, 180 minutes, was considered for the calculation. The value of C was calculated by interpolation from the Runoff Coefficients table mentioned in CPHEEO [3] and was found to be equal to 0.612. The value of intensity was calculated from Fig. 4 corresponding to 180 minutes and was found to be approximately equal to 19mm/hr.

After obtaining the values of C, A and I the peak flow was calculated using (1) and was found to be 3255.84 $m^3$/hr.

## V. DESIGN LAYOUT AND DATA

### A. Data Entered

After choosing GVF-Convex Solver and changing the unit setting to Standard International, the schematic drawing mode was selected so that pipe lengths could be manually entered. Then the network layout was made in accordance to the Sewerage Master Plan Delhi- 2031 which was obtained from Delhi Jal Board. A suitable outfall was laid out and a sample network of Catchment-3, consisting of 11 manholes was made. The following data as obtained from the Delhi Jal Board was entered into the hydraulic model[5].

- Ground Elevations and Invert Elevations- The start node of invert elevation of the outfall was taken as 0 by default and the stop node of invert elevation was taken as 214.91 meters. All other values of the elevations were entered for all the manholes as per the hydraulic sheet[5].
- Conduit Properties- The pipes used in the project are DWC (Double Walled Corrugated) pipes. SewerGEMS provides an option of HDPE (High-density polyethylene) Corrugated Smooth pipes closest to it in properties and structure and hence, they were used for the hydraulic modeling.
- Pipe Length- Pipe length here refers to the distance between two consecutive manholes. The maximum distance between two manholes is usually 15 meters. However, in case of extra loading in certain location, manholes might be placed more closely.
- Pipe Diameter- The pipe diameter used is 250 mm and is uniform throughout the network.

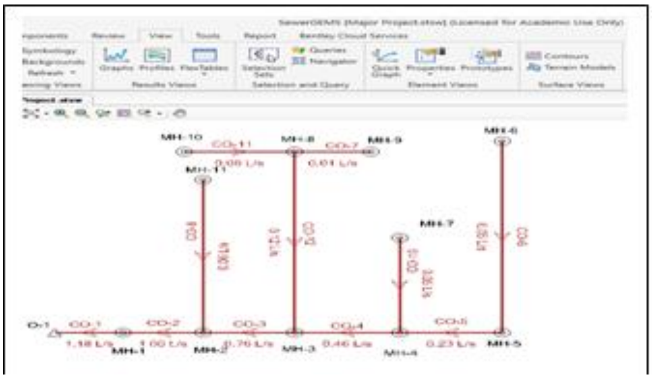

**Fig 5. Network Layout of the sewerage lines**

### B. Loads

SewerGEMS provides an inbuilt library of unitary loading values based on the type of institutions or buildings. The catchment under consideration has been observed to have the following combination of buildings and their respective loading has been depicted below.

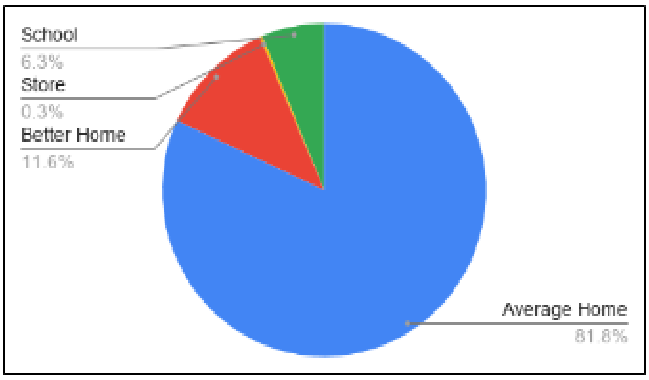


**Fig 6. Sanitary Loading of the catchment**

The respective unit loads were entered into the Sanitary Load Control centre and the model was validated and then computed.

## VI. RESULTS

The sample hydraulic model was successfully run and there were no validation errors. SewerGEMS provides the user notifications regarding the probable errors in the designing or the futuristic possibility of facing design issues. The user notifications flashed only yellow warnings which do not signify any error with the design values but only mean that the properties do not meet the default constraint criteria of the software and hence, can be ignored. The next step was analyzing the various parts of network and calculating average daily flow and peak flow of sewerage in individual manholes. This was easily done by generating the graphical underground profile of any part of the network. The average daily flow profile sample between MH(Manhole)- 5 and MH- 10 has been shown below.

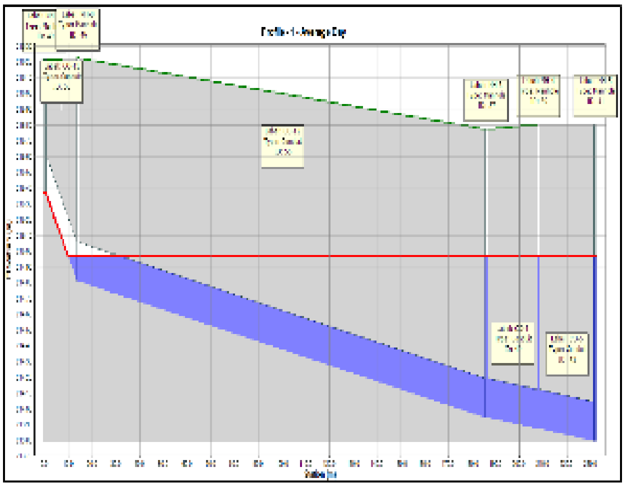

**Fig 7. Average Daily profile**

The graph is plotted between the station distance and elevation both in meters and the red line in the profile displays the HGL(Hydraulic Gradient Line) while the top green line indicates the ground level. In case of pressure pipes, EGL(Energy Gradient line) is also displayed. The blue colored channel depicts the underground sewage conduit. The peak flows of all the conduits were obtained and the following result was drawn:

**Table II. Peak flow in conduits**

| | |
|---|---|
| Percentage of conduits with peak flow < 1L/s | 63.63 |
| Percentage of conduits with peak flow > 1L/s | 36.36 |

Similar analysis can be done for larger networks and better knowledge can be attained about the velocity of sewage in different areas.

## VII. CONCLUSION

- The curvilinear method for the population forecast is effective as it considers past population trends specially when there is no expectation of decline in future population as it is a developing area like Utsav Vihar.
- The division of area into catchments is beneficial in determining the sanitary loading essential for further determining the velocity and slope using SewerGEMS Software.
- SewerGEMS software provides a fully fledged option of creating IDF curve by just entering obtained rainfall intensity data and is of much use for the designer.
- SewerGEMS software helps the user in avoiding any error or misreading in elevation values or selection of pipe lengths and diameters by a series of notifications indicating the problem caused and the severity of the issue raised with differently coloured flags.
- The software also generates average daily and peak flow profiles of individual conduits as well as networks which is beneficiary for studies and analysis. Modifying the network according to the requirement of the user at any point of time is also possible with this software, without any huge economic or physical loss.

## ACKNOWLEDGEMENT

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