Sewer System Design required and the Design criteria

Reeta Chhachhiya

(B.E. EngineeringCollege of Kota Rajasthan ,Mtech In environment MNIT Jaipur)
Guest Assistant Professor at Jafferpur engineering College New Delhi

Abstract: The design of sewer system design is a large scale optimization problem, involving many complex calculations. Recently, this problem has been compounded by the evident need to embrace more than a single measure of performance into the design process, since by nature multi-objective optimization methods require more iteration .these problem properties have motivated several prier studies to use computational software's because these software's have been shown to obtain higher quality solutions for large sewer system design problems. They do not require much time in order to achieving a satisfactory solution. Hence the use of design software's for design of an Sewer system could be a remedy to this problem. These specific software's are capable of achieving a satisfactory level of performance with limited number of function evaluations represent a valuable alternative. A sewer system is an underground conduit or drain though which sewerage is conveyed to the point of discharge or disposal. many design & construction factors need to be considered before sewer design can be completed .factors such as design period , peak ,average , minimum flows ,sewer slopes ,minimum and maximum velocities ,design equation, sewer material ,joints and connection, appurtenance and sewer installation etc. are all important in developing sewer design. In this study sewer cad software is being used for designing problem of a real medium size sewer system for kota city Rajasthan .Results obtained suggest that the use of sewer CAD software could be successfully extended to the efficient design of large scale sewer systems.

Index items-Sewer System Sewer Design, Software, Design Criteria, and parameters.

1. Introduction

Every community is to control both liquid and solid wastes. the liquid portion of the waste is basically the used up of water supplied to the community, duly been fouled as waste water by verity of uses .thus wastewater may be considered to have been generated at different sources such as residences, institutions, commercials and Sewer System establishments together with apportion of ground water along water carrying wastes from such generations found in it. if the above waste water is allowed to remain shell result the following adverse effect to the environment.

a) Decomposition of stagnant organic material shell lead to the production of large quantity of odorous and pollutional gases
b) Stagnant waste containing toxic and hazardous ingredients may affect the ecosystem adversely.

Thus the main objectives of proper wastewater disposal are:

1. To prevent public health.
2. To prevent adverse conditions caused by discharge of pollution to the environment.
3. To limit the disposal of waste onto land.

For safely disposal of waste water and domestic waste water, we require to dispose the waste water carefully through a network of pipeline known as the sewer lines which carry the waste water to the waste water treatment plant. These sewer lines which carry the wastewater to the waste water treatment plant. These sewer lines are provided with specific discharge rates depending upon the population and utility of the particular region. The 21st century is called to be a compute century .the computer is a device, which works accurately, fast and efficiently .Now due to computer the work done by hundreds of people and taking months.

2. Background

Kota is an important industrial town of Rajasthan located on the banks of River Chambal. The main part of the city is located on its right bank consisting of the old city area and the railway station. The area on the left bank has developed around the development of a thermal power station. The major development of the city came with the development of the various industries in the 50's and 60's when factories like the Sri Ram Fertilizers, J. K. Synthetics came up. The last two decades have seen a phenomenal development of educational coaching centers and is likely to culminate with locating an Indian Institute of Technology in Kota. The location of the city on the banks of the river Chambal with the Barrage constructed on it with in the city area makes access to reliable and easy availability of water. This has given it the distinction of being one of the very few cities in India having 24 hour water supply on taps. This in turn creates a good quantity of sewage which for the time being is practically going into the river through drains.

This problem has been attracting attention de to the unhygienic conditions it creates in the city and also the pollution it creates in the river. Earlier in the 80's an effort was made to prevent pollution of the river by constructing sewage pumping stations for intercepting the drains and pumping the sewage through a 1000 mm diameter outfall sewer leading to the then proposed site of the sewage treatment plant at Kanswa Nala. Few sewers were also laid in a small segment of the city near the station area. The works were carried out by the Public health Engineering Department of Rajasthan and were handed over to the Municipal Corporation of Kota for Operation and Maintenance. The State under the Rajasthan Urban Infrastructure Development Project took up work for upgrading the main sewer from Ambedkar circle to Anta Ghar crossing, construction of the out fall sewer from Kanswa Nala to the site for STP now finalized and acquired land at Dhakar Kheri for construction of Sewage Treatment Plants (STP) for the city on the right bank. It also took up construction of 20 MLD STP and laying mains and laterals in the station area involving construction of 5 pumping stations. The works are in progress. This would benefit 10.44 % of the total population of 2001 and only a part of the segment of population draining in the river on downstream of barrage. The State has also approached the

Ministry of Environment Government of India for assisting the development of the sewerage system of the areas of the city which are draining into the river Chambal within the municipal area under the National River Conservation Plan (NRCP).
The city has 60 yards and a population of 7,03,150 as per the 2001 census out which 32 (30 on right bank and 2 on left bank) wards covering a population of 2,39,456 (2,10,836 on right bank and 28,620 on left bank) drain towards the river. Thus about 35.62 % population is directly draining its waste water in the river. This includes both the banks of the river. These areas have been proposed to be covered under the NRCP Project. The Project constitutes of about 25.0 km of outfall and trunk mains, 194 km of laterals, 11 pumping stations and two sewerage treatment plants of 30.0 and 6.0 MLD capacities. The final shape will emerge after the project is approved by the Ministry of Environment but as is indicated by them, they are not likely to finance the laterals under their approval as a matter of policy.
It is now proposed to cover a major part of the remaining city area under UIDSSMT in this Project.

3. General topography

The area to be covered is very typical and difficult in view of the existing congested property along the streets, narrow lanes, and very hard rock sub strata. The experience of the laying of water pipe lines and sewer in the city in RUIDP works has highlighted the problems encountered in the excavation of the sites. The associated inconvenience to the citizens for prolonged periods has attracted high criticism. It is not possible to blast the rock in the city area and the chiseling of the rock has proven to be very expensive and time consuming even for shallow trenches of 1 to 1.5 m done for the drinking water pipe lines. The deeper excavations required for the sewers particularly in the Sree Nath Puram to Kishorepura Gate section and Old City area and also in the Left Bank will be a tedious work. It highlights the need to make an effort to invite advanced technology for the work (mechanized excavation/micro tunneling) from experienced contractors from within the country or abroad. This change is required to ensure completion of the work in some reasonable time.

4. DESIGN PARAMETERS FOR SEWERAGE SYSTEM: DESIGN PERIOD

The Design period for a sewerage scheme is generally taken as 30 years. The Project is likely to be completed by the year 2011 and accordingly 2041 is kept as the Design year. The various system components shall have the Design period as described below:

S.no.	Description	Design Period	Remarks
1	Sewage collection system i.e. (Laterals/branch/Main sewers), and out fall sewers	30	
2	Sewage pumping stations a) Civil works b) Pumps	30 15	
3	Sewage pumping main	30	
4	Sewage Treatment Plant	30	Modular construction with stage wise enhancement of capacity

a. Peak Factor

Flow in sewers varies from hour to hour and seasonally. For purpose of hydraulic design estimated peak flows are adopted. As per manual ratio of maximum to average are as follows: (As per clause 3.2.5 of manual CPHEEO).

Contributory population	Peak factor
Up to 20,000	3.0
20,000 to 50,000	2.5
50,000 to 7,50,000	2.25
above 7,50,000	2.00

b. Hydraulic Formulae:

Manning's formula is used for preparation of Hydraulic designs.
The general expression of the Manning's formula is

$$V = 1/n\ (R\ 2/3)\ (S1/2\ )$$

For circular sewers the formula takes the following forms

$$Q = 1/n\ \ 3.118 \times 10 -6\ d\ 8/3\ S1/2 \qquad V = 1/n\ \ 3.968 \times 10 -3\ d\ 2/3\ S\ 1/2$$

Where V = velocity in pipe in m/s
Q = discharge in liters/sec, d = diameter of pipe in mm
S = slope of hydraulic gradient , R = hydraulic radius in meters. n = Manning's coefficient
Manning's coefficient is considered as 0.011 RCC pipes with rubber rings joint.

c. Depth of flow:

All sewers are designed for the maximum depth of flow of 0.8 full at ultimate peak flow

d. Minimum and Maximum Velocities:

Generally the sewers shall be designed to have self-cleansing velocities to avoid silting. The sewers shall be designed to have minimum velocities as below.
0.60 m/sec for present peak flow.
Part of the main sewer has velocities less than 0.80 m/sec, but higher than 0.75 m/sec on design peak flows. This has been considered acceptable to avoid deep sewers in rocky strata. The initial design is done for the design peak and then checked for the minimum flow velocity of 0.6 m/s for the present peak in main sewers. The flushing arrangement will be used for the initial stretches where minimum velocity may not be developed.
The maximum velocity of 3m/sec shall be used to avoid scouring of sewers.

e. *Minimum Size of sewers:*

It is proposed to use a minimum size of sewers for 200 mm for following reasons: The most commonly used option for material of pipe is RCC due to difficulty in procurement of SWG pipes in the area. The SWG pipes being mortar jointed, take a long time in setting and becoming available for testing in field which is not acceptable in crowded populated areas. The RCC pipes used in 150 mm have very serious problem in quality during casting which the local manufacturer have not been able to set right during the course of construction for RUIDP. The pipes of sizes 200 mm and above are satisfactory. It is now very frequently that the sanitary napkins are flushed in the sewers which cause blockages frequently in the 150 mm sewers whereas the 200 mm sewer does not have this problem. The minimum slope to be provided in the laterals which do not have self cleansing velocities is such which will permit the self cleansing velocity when flushed. The slope required is less in case of 200 mm compared to 150 mm which saves excavation. This is important particularly in this rocky area. The present trend is of vertical construction and the loads on the system tend to increase suddenly wherever this happens. The 200 mm sewers cope with it much more easily.

f. *Shallow Sewers:*

The shallow sewers have been proposed in the city area to avoid cutting in hard strata on narrow roads. The sewers are proposed on roads having minimum width of 1.50 m. It is proposed to provide minimum invert depth of 0.60m for the minimum pipe diameter of 200 mm.This is based on the recommendations of CPHEEO manual for laying sewers in difficult areas. To facilitate house connections the minimum invert depth for various road widths is proposed as below.

i) For roads with width up to 2.50 m - 0.45 m
ii) For roads with width from 2.51 m to 4m - 0.60 m
iii) For roads with width exceeding 4 m - 0.80 m

g. Width of Trench

The majority of the roads are very narrow with highly developed residential and/or commercial areas. Therefore, the width of the trench needs to be restricted for the following reasons.

- To cause minimum disturbance to adjoining facilities/utilities, especially in densely developed areas of the old city.
- To reduce cost of excavation and restoration of road surface.
- To reduce the period for installation of sewers

The trench width has been standardized as the width of outer diameter plus 300 mm at the pipe bottom level.

Bedding:

As a part of shallow sewers, the sewers are proposed to be completely encased in concrete on roads having width more than 2.50 m and where invert depths are less than 0.80 m. The cement concrete of M - 15 grades shall be used. The sewers on the road having width more than 2.50 m and invert depths more than 0.80 m shall be provided with bedding as per standard drawing for bedding.

h. Sewer Transition

Sewer Transition occurs at location where there is change in grade and/or diameter. This results in loss of energy for which necessary drop shall be provided in the manhole which, shall be constructed at every transition

Transition from smaller to larger diameter sewers shall be done by always matching crowns i.e. crowns are generally kept continuous except in extra ordinary conditions.

i. Manholes:

The narrow roads in the project area make it imperative to use manhole chambers, which can be safely constructed and properly maintained. Even though stone is locally available material, it is not suitable for very small size manholes to be constructed on narrow streets. All these factors have been taken in to consideration and the different manhole types have been adopted. The maximum standard spacing of manholes on straight reaches is 30 meters. It is proposed to provide manholes at an interval of 15 meters on roads having width up to 4 meters. On roads having widths higher than 4 meters the maximum manhole spacing shall be 30 meters. For sewers more than 450 mm dia. the spacing of manholes will be more than 50 m. and less than 100 m. depending on the site condition.

The other criteria for manhole spacing are: -

- Manholes at all intersections will be provided irrespective of distance criterion.
- Manholes will be provided to meet with change of alignment irrespective of distance criterion.

Typical manholes frame and cover would be steel fiber reinforced concrete as per I.S. 12592 (Part I & II).

Scrapper type manhole are proposed on sewers of 450 mm and above at about 120m spacing

j. h.Drop Arrangements:

Generally drops are proposed for sewer line of dia 200 to 300 mm. Drop Arrangement will be provided where difference between two sewers is greater than 600 mm. In the drop portion, pipes & special of uPVC class 3 will be used. u PVC Pipes will be encased with PCC wherever necessary. However diameter greater than 300 mm, a maximum 600 mm drop (free fall) in a manhole shall be permitted.

Types of Manholes

Sewer Diameter mm	Invert Depth m	Internal diameter of Man hole m	Construction	Type
< 700	Upto 1.65 1.65 – 2.5 2.50 – 5.0 5.0 – 9.0	0.9 1.2 1.5 1.5	Stone Masonry	A B C D
=> 700	Upto 1.80 1.80 – 3.50 3.50 – 8.0	1.5 1.5 2.0	Reinforced Cement Concrete	E E F

k. Ventilating Shaft

The ventilating pre-cast concrete shaft of 9 m height is proposed. A typical drawing of ventilating shaft is enclosed. It is proposed to provide ventilating shaft on sewers 400mm diameter and above and at a distance of approximately 200 m center to center and at strategic locations.

l. Pipe Material

All pipes adopted for the project shall be R.C.C. spun cast pipes with spigot and socket ends to be jointed through a rubber sealing ring type. The pipes shall be manufactured as per I.S. 458. The cement to be used for R.C.C. pipes shall be ordinary Portland cement in confirmation to I.S. 12330. The rubber rings to be provided shall be as per I.S. 5382. The appropriate class is proposed to be used based on diameter; invert depth and class of bedding.

u PVC Pipes: u PVC pipes of class 3 are proposed to be used for property connection of size 110 & 160 mm outer dia pipes. For a single house connection 110 mm pipes and for multiple house connection 160 mm u PVC pipe shall be used. These pipes are also proposed for the drop arrangement.

m. Property Connections:

The work of laying the connecting pipes for the Property connections is proposed in this Project to facilitate and encourage the consumer to get connected for conveyance of wastewater from properties to the street manholes. In this Project, the property connection work includes providing and laying of the connection pipe of uPVC (class 3) from the property line to street manhole. The pipe will be left plugged at the consumer end. The work of connecting the pipe to house collection chamber (IC) within the property premise is not included in this contract and this wok has been left with individual property owner. The size of pipe shall be 160 mm OD for two properties and 110 mm for single property.

This will prevent frequent breaking of the road every time someone decides to get connected, will save falling of debris in manholes which generally happens when connections are made later.

The property connection is proposed directly to manhole as Y and T connections are not possible on RCC pipes. The average depth of property connection shall generally be in accordance to the depth of sewers and not more than 1.0 m.

5. **Sewer system designing using SEWER CAD :Design Approach**: Designing sewer system by using SEWER CAD is more efficient than conventional methods; it utilizes less input data and provides the data in Avery short duration of time interval. The user needs to input the following data for designing of sewer system by utilizing SEWER CAD.

Main Inputs are:

- Auto Cad drawing which has to convert in to DXF. Format.
- Set the units in Meters or inch.
- Draw the Network Layout according to Upstream to Down Stream side .Finally connected to all by main outlet say STP (Sewerage Treatment plant).The minimum Pipe Length 30 m not less than it.
- Give Ground Levels (G.L.) At all Manholes.
- Describe a population density for particular area, it's (Population/area).
- Detail data of Sewer System demand, so that finalized the total sewer generated.
- After finalizes the Sewer System demand finalized the Sewer System sewerage treatment plant capacity, made a table each sewer flow so that flow given to nodes.

There are inputs for pipe material N value for that, minimum to maximum size of pipe say from 150 to 1000 mm, minimum to maximum slope for pipes say 1/2000 to 1/150. Minimum to maximum cover say (o.80m to 2.0 m).These all data along with flow tables are directly imported in the SEWERCAD software for its design and run the project. After much iteration we have to find out the unique optimize solution in which we get design velocity, sufficient depth according the site and appropriate maximum size of sewer. The calculations have been done within the software after finding the all data. The result of design given in the excel.

Summary of Sewerage system

A detailed abstract of the sewer pipes to be laid in different depths has been prepared for each zone and part and is enclosed in the Design Chapter. In brief the total length of the sewer to be laid in this project **Table-5.1**

Table-5.1

Sizemm	Length(M)	Class of Pipe
200	105804	NP-4
250	5874	NP-4
300	5096	NP-2
350	260	NP-2
400	7157	NP-2
450	4962	NP-2
500	828	NP-2
600	2400	NP-2
700	2201	NP-4
800	1225	NP-4
900	135	NP-4
1000	2275	NP-4
1100	1347	NP-4
1200	785	NP-4
1400	1129	NP-4
TOTAL	141478	

Conclusion

Software "SEWER CAD" was found to be more efficient and faster than conventional designing method, as was be in accordance with the calculations as per formulas given in Chapter 3.4.5 of CPHEEO manual 1993. Auto CAD drawing is essentially required for designing with SEWER CAD, as the AUTO CAD drawing is directly imported into the SEWER CAD software, it is also required for getting ground levels for base of designing for all data. The maximum peak flow gives the value of discharge of an effluent to be finally disposed off. Therefore, helps in determination of the total capacity of an effluent treatment plant to be installed in a particular low laying area and proper land is available for STP .we can have check the old existing outfall capacity ,if its not suitable replace by new one. Overall ,this study suggests that SEWERCAD is a promising way forward to solving network design problems when time or financial considerations allow for a limited number of hydraulic simulations to be performed .it's good performance, coupled with a simple implementation and relative to more standard approaches for successfully applied to reduce the number of expensive simulations required when the complexity of design problem is small to medium in terms of number of pipe sizes .therefore, it can be concluded that application of design software's in civil engineering design is more fruitful than to conventional design criteria.

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