



Design of Sanitary Sewer Systems

An Online Continuing Education Course for Engineers

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Design of Sanitary Sewer Systems

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I. INTRODUCTION

Sanitary sewer systems are essential for the public health and welfare in all areas of concentrated population and development. Every community produces water-borne wastes of domestic, commercial, and industrial origin. Sewers perform the functions of collecting these wastes and conveying them to points of discharge or disposal.

I.1. Classification of sewers

Sewer is a pipe or conduit that carries wastewater. Sanitary sewer is one that carries liquid and water-borne wastes from residences, commercial buildings, industrial plants and institutions. They are further classified as follows:

I.1.1. Relief sewer – A sewer built to carry the flows in excess of the capacity of an existing sewer.

I.1.2. Building sewer – The pipe connecting the building drain with the public sewer or other places of disposal. It is also called house connection.

I.1.3. Lateral sewer – A sewer that discharges into a branch or other sewer and has no other common sewer tributary to it.

I.1.4. Branch sewer – A sewer that receives wastewater from a relatively small area and discharges into a main sewer serving more than one branch-sewer area.

I.1.5. Sub-main sewer – A sewer into which the wastewater from two or more lateral sewers is discharged and which subsequently discharges into a main sewer.

I.1.6. Main sewer – In large systems, the principal sewer to which branch sewers and sub-mains are tributary. It is also called a trunk sewer.

I.1.7. Intercepting sewer – A sewer that receives flow from a number of transverse sewers or outlets and conducts the flow to a point for treatment or disposal.

I.1.8. Outfall sewer – A sewer that receives wastewater from a collection system or a treatment plant and carries it to a point of final discharge.

I.2. Phases of sanitary sewer system development

The following phases comprise the development of a typical sewer system:

1. Preliminary or investigative phase
2. Design phase
3. Construction phase
4. Operation phase

I.3. Parties involved in sanitary sewer systems

The following parties are involved in a typical sewer system project:

1. Owner
2. Engineer
3. Contractor
4. Legal counsel
5. Financial consultant
6. Regulatory agencies

II. SURVEYS AND INVESTIGATIONS

Surveys and investigations produce the basic data necessary for a sewer system project. “Survey” refers to the process of collecting and compiling information necessary to develop a project. “Investigation” usually refers to assimilation and analysis of the data produced by surveys for arriving at engineering decisions.

II.1. Types of information required

The following types of information are generally required for a sewer system project:

II.1.1. Physical – Includes Topography, surface conditions, details of paving to be disturbed, underground structures, subsoil conditions, water table details, details of existing system to which a proposed sewer may connect, location of streets, alleys or unusual obstructions, required rights-of-way and pertinent information relative to possible future extension of the proposed project by annexation or service agreements with adjacent communities or areas.

II.1.2. Developmental – Includes population trends and density in area to be served, type of development such as residential, commercial or industrial, quantity and strength of wastes from industrial contributors, water use data, location of future roads, airports, industrial areas that may affect the routing and location of sewers and capacity and condition of existing sewer system.

II.1.3. Political – Includes present political boundaries and probability of annexation of adjacent areas, possible service agreements with adjacent communities, existence and effectiveness of industrial waste ordinances, and effectiveness and adequacy of present political subdivision to undertake the project.

II.1.4. Financial – Includes information relative to existing policies, obligations, or commitments bearing on financing of proposed sewers, amounts and retirement schedule of outstanding bonds, availability of federal or state grants or loans, schedule of existing sewer service rates with revenues, property plats as required for sewer assessments, and local construction and operating conditions affecting cost.

II.2. Source of information

Possible sources of the different types of information sought by surveys for sewer system projects include:

II.2.1. Physical – Existing maps and system plans, city plats and topographic maps, state highway plans and maps, US Geological Survey topographic maps, local utility records and plans, aerial photographs, and boring and test pits to indicate sub soil conditions.

II.2.2. Developmental – Includes census reports, planning and zoning reports, sampling data in existing sewers to establish flow characteristics from similar areas, records of water use, design basis with operational characteristics of existing sewers from system records, and criteria of regulatory agencies.

II.2.3. Political – Includes municipal and state laws, conferences with owner as well as other officials, comprehensive plans established by planning agencies, and local area meeting reports.

II.2.4. Financial – Includes pertinent records of the owner’s fiscal officer, auditor’s records for tax levies, ordinances for outstanding bonds, tax maps showing subdivisions and ownership of property to be affected by special assessments, and methods used for assessment of previous projects.

III. QUANTITY OF SANITARY SEWAGE

Sanitary sewers are provided to carry the spent water supply of a community, including industrial and commercial wastes, to a point of treatment or ultimate disposal. Connection of roof, yard, and foundation drains to the sanitary sewers must be strictly prohibited. The sewer capacity to be provided must be determined from careful analysis of the present and probable future quantities of domestic and industrial wastewaters, and ground water infiltration.

III.1. Design period – The design period is defined as the length of time throughout which the capacity of the sewer will be adequate. For large sewers, past and future trends in population, water use, and existing wastewater flows must be studied to establish the design period. It must be established prior to the design of the sewer. Once established, consideration must be given to the quantity of wastewater to be handled. Because the flow is largely a function of population served, population density, and water consumption, lateral and sub main sewers must be designed for peak flows corresponding to the population at saturation density as set forth in the community’s master plan or otherwise predicted. Anticipated maximum water-use rates and population density may be used as a guide in determining maximum sewage flows. Trunk sewers, interceptors, and outfalls are commonly designed for the peak flow expected at least 25 to 50 years in the future.

III.2. Population estimates – It is customary to multiply the future tributary population by the probable per capita sewage contribution. So, the accuracy of the population estimate is extremely important in this computation. In addition to their immediate value in estimating flows, future population estimates influence the choice of the design period. Future population trends depend on many factors as shown below:

1. Location with respect to transportation facilities
2. Raw materials and manufactured products
3. Possible expansion of present industries
4. Availability of sites for residential, commercial, or industrial development

5. Civic interest in community growth
6. Availability of other utility services at reasonable rates
7. Real estate values

The most widely employed mathematical or graphical methods for extending past municipal population data are:

1. Arithmetic progression or uniform growth rate
2. Constant- percentage growth rate
3. Decreasing rate of increase
4. Graphical comparison with the growth rates of similar cities
5. The use of mathematical trends such as the logistic curves

The above methods are described in detail in the following sections.

III.2.1. Arithmetic progression – This method of estimation is based on a constant increment of increase and may be stated as follows:

$$\frac{dy}{dt} = K_u$$

where y = population

t = time (usually years)

K_u = uniform growth-rate constant

If Y_1 represents the population at the census preceding the last census (time t_1), and Y_2 represents the population at the last census (time t_2), then

$$\int_{y_1}^{y_2} dY = K_u \int_{t_1}^{t_2} dt$$

Integrating and inserting the limits, the following equation is obtained

$$Y_2 - Y_1 = K_u (t_2 - t_1)$$

Therefore,

$$K_u = \frac{Y_2 - Y_1}{t_2 - t_1}$$

Using the above equation, the expression to estimate the population at the end of the forecast period t is

$$Y = Y_2 + \frac{(Y_2 - Y_1)(t - t_1)}{(t_2 - t_1)}$$

III.2.2. Constant-percentage growth rate – For equal periods of time this procedure assumes constant growth percentages. If the population increased from 90,000 to 100,000 in the past 10 years, the increase is 11 %. It is assumed that the same percentage increase will prevail in the ensuing decade. Hence, the growth in the ensuing decade is estimated to be $100,000 + 0.11 \times 100,000$ or 111,000. Mathematically, the constant percentage increase per unit time. Integrating the

$$K_p = \frac{\log_e Y}{t_2}$$

$$\log_e Y = \log_e$$

Logarithm to base 10 n

III.2.3. Decreasing rate
increase assume a varia
may be formulated as

$$\frac{dY}{dt} = K_D(Z - Y)$$

where K_D represents a constant percentage of a decrease per unit time

Z represents the saturation or limiting value that must be estimated and the other variables are as defined in paragraph III.2.2, above.

Then,

$$\int_{y_1}^{y_2} \frac{dY}{Z - Y} = K_p \int_{t_1}^{t_2} dt \text{ and upon integration,}$$

$$-\log_e \frac{Z - Y_2}{Z - Y_1} = K_p (t_2 - t_1)$$

