PROJECT REPORT

ON

DESIGN OF SEWERAGE SYSTEM FOR RAJIV GANDHI NATIONAL LAW UNIVERSITY (RGNLU), PATIALA

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CERTIFICATE

This is to certify that project report entitled "**DESIGN OF SEWERAGE SYSTEM FOR RAJIV GANDHI NATIONAL LAW UNIVERSITY (RGNLU), PATIALA"**, submitted by **ROHIN GUPTA** in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date: **Supervisor's Name**

Designation

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ABSTRACT:-

In sewerage system the function of carrying sewage is done through well planned distribution system choosing suitable diameter of pipes as it comprises the major investment in the system. Analysis and design of a pipe network system is a complex and time taking work. In this report a simple method is discussed which can be used suitably for optimal design of pipe networks for the sewerage system. The problem has thus been solved with a view to reduce the total cost of pipe network satisfying the required amount discharge in the outlet. Manning's Formula has been used for estimating the required discharge in each outlet of the pipe network, and optimization of the system has been done to reduce the cost with the help of Microsoft-excel. Separate collection system for collection of storm water and sewage is used. A study on untreated waste water and treated effluent has been performed. The present study involves the analysis of pH value, total solids, total suspended solids, hardness, acidity, alkalinity, chloride, chlorine, BOD, DO, COD, etc.

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CHAPTER 1

INTRODUCTION

1.1 General

Most urban areas inhabited by slums in the country are plagued by acute problems related to indiscriminate disposal of sewage. Due to deficient efforts by town/city authorities, sewage and its management has become a tenacious problem and this is notwithstanding the fact that the large part of the municipal expenditure is allotted to it. Large quantity of sewage remains unattended giving rise to insanitary conditions in especially densely populated slums which in turn results in an increase in morbidity especially due to pathogens, parasitic infections and infestations in all segment of population particularly with the urban slum dwellers.

Sewerage and sewage treatment is a part of public health and sanitation, and according to the Indian Constitution, falls within the purview of the State List. Since this is non-exclusive and essential, the responsibility for providing the services lies within the public domain. The activity being of a local nature is entrusted to the Urban Local Bodies(ULBs), which undertake the task of sewerage and sewage treatment service delivery, with its own staff, equipment and funds.

1.2 Need for Safe Sanitation System

Sanitation can be perceived as the conditions and processes relating to people's health, especially the systems that supply water and deal with human waste. Such a task would logically cover other matters such as, solid wastes industrial and other special/hazardous wastes and storm water drainage. However, the most potent of these pollutants is the sewage. When untreated sewage accumulates and is allowed to become septic, the decomposition of its organic matter leads to nuisance conditions including the production of malodorous gases. In addition, untreated sewage contains numerous pathogens that dwell in the human intestine tract. Sewage also contains nutrients, which can stimulate the growth of aquatic plants, and may contain toxic compounds or compounds that are potentially mutagenic or carcinogenic. For these reasons, the immediate and nuisance-free removal of sewage from its sources of generation, followed by treatment, reuse, or dispersal into the environment in an eco-friendly manner is necessary to protect public health and environment.

1.3 Present Scenario of Urban Sanitation in India

The problem of sanitation is much worse in urban areas due to increasing congestion and density in cities. Indeed, the environmental and health implications of the very poor sanitary conditions are a major cause for concern. The study of Water and Sanitation Program (WSP) of World Bank observes that when mortality impact is excluded, the economic impact for the weaker section of the society accounting 20% of the households is the highest. The National Urban Sanitation Policy (NUSP) of 2008 has laid down the framework for addressing the challenges of city sanitation. The Policy emphasizes the need for spreading awareness about sanitation through an integrated city-wide approach, assigning institutional responsibilities and due regard for demand and supply considerations, with special focus on the urban poor.

1.4 Sewerage and Sewage Treatment Technology

Sewerage and Sewage treatment technology is the branch of environmental engineering in which the basic principles of engineering are applied to solve the issues associated with the collection, those of biochemistry are applied to the treatment and environmental issues are applied in the disposal, and reuse of treated sewage. The ultimate goal is the protection of public health in a manner commensurate with environmental, economic, social, and political concerns. To protect public health and environment, it is necessary to have knowledge of:

1. Constituents of concern in sewage

2. Impacts of these constituents when sewage is dispersed into the environment,

3. The transformation and long-term fate of these constituents in treatment processes,

4. Treatment methods which can be used to remove or modify the constituents found in sewage, and

5. Methods for beneficial use or disposal of solids generated by the treatment systems.

1.5 Initiatives of government of India

Government of India has taken number of initiatives during the last two decades by implementing number of reforms aimed at improving the working efficiency of ULBs in India. These reforms have been implemented in the form of Act (Amendment) and all the State Governments have been advised to implement these reforms by suitably modifying ULB’s bye laws so as to achieve the objectives of these reforms for the development of urban sector in the country. Few of the reforms such as institutional reform, financial reforms, legal reforms, etc., are in vogue. Reforms mainly relating to sewerage and sanitation are briefly described as under:

1.5.1 74th Constitution Amendment Act, 1992

As per the 74th Constitution Amendment Act, 1992, the ULBs have been delegated with sets of responsibilities and functions. But they are not supplemented with adequate financial resources. They are also not able to fix the rates of users' charges and are heavily dependent upon the higher levels of Governments grants. The 74th CAA has substantially broadened the range of functions to be performed by the elected ULBs. The Constitution thus envisages ULBs as being totally responsible for all aspects of development, civic services, and environment in the cities, going far beyond the traditional role.

1.5.2 Liberation of Manual Scavengers

Government of India has enacted the Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act, 1993. It serves as a primary instrument to eradicate practice of manual scavenging. The Centrally sponsored scheme of Urban Low Cost Sanitation for liberation of the scavengers was started in year 1980-81, which is now being operated through the Ministry of Housing and Urban Poverty Alleviation.

1.5.3 National Urban Sanitation Policy (2008) of government of India

The salient features of Urban Sanitation Policy are as follows:

a) Cities must be open defecation free

b) Municipal sewage and storm water drainage must be safely managed

c) Recycle and reuse of treated sewage for non-potable applications should be implemented wherever possible

d) Solid waste collected and disposed of fully and safely

e) Services to the poor and systems for sustaining results

CHAPTER 2

PLANNING OF SEWERAGE AND DRAINAGE SYSTEM

2.1 Vision

The vision for urban sanitation in India as mentioned in the National Urban Sanitation Policy(2008) of Government of India is:

All Indian cities and towns become totally sanitized, healthy and liveable, and ensure and sustain good public health and environmental outcomes for all their citizens with a special focus on hygienic and affordable sanitation facilities for the urban poor and women.

2.2 Objectives

The objective of a sewage collection, treatment and disposal system is to ensure that sewage discharged from communities is properly collected, transported, and treated to the required degree in short, medium, and long-term, and disposed-off / reused without causing any health or environmental problems.

Short term: It implies immediate provision of onsite system. It should be formulated targeting up to 5 years from the base year.

Medium term: It implies the provision of a decentralized system of collection for rapid implementation of collection, transportation, treatment, and disposal/local reuse to avoid sporadic sewage discharges into the environment and should have a target of 15 years from the base year.

Long term: It implies conventional sewage collection, transportation, treatment,and environmentally sound disposal/reuse.It encompasses the short term and medium term. These plans should be formulated for a target of 30 years from the base year.

2.3 Need For Planning

Sewage collection, treatment and disposal systems can be either the short-term, or medium-term or long-term. To keep overall costs down, most urban systems today are planned as an optimum mix of the three types depending on various factors. Planning is required at different levels: national, state, regional, local and community. Though the responsibility of various organizations in charge of planning sewage collection, treatment and disposal systems is different in each case, they still have to function within the priorities fixed by the national and state governments and keep in view overall requirements of the area.

2.4 Basic Design Considerations

2.4.1 Engineering considerations

2.4.2 Institutional aspects

2.4.3 Environmental considerations

2.4.4 Treatment process

2.4.5 Financial aspects

2.4.6 Legal issues

2.4.1 Engineering Considerations

Topographical, engineering and other considerations which figure prominently in project design are noted below:

a) Design period, stage wise population to be served and expected sewage flow quality and fluctuation

b) Topography of the general area to be served, its slope and terrain, and soil profiles affecting construction.

c) Soil bearing capacity and type of strata expected to be met with in construction

d) On site disposal facilities

e) Existing water supply, sewerage and sanitation conditions

2.4.2 Institutional Aspects

a) Capability of existing local authority

b) Revenue collection and reliability

c) Capacity building needs

d) Public Private Partnership.

2.4.3 Environmental Considerations

a) Surface Water Hydrology and Quality

b) Ground Water Quality

c) Coastal Water Quality

d) Odour and Mosquito Nuisance

e) Public Health

2.4.4 Treatment Process

a) Sewage Flow and Characteristics

b) Degree of Treatment Required

c) Performance Characteristics

d) Other Process Requirements

2.4.5 Financial Aspects

a) Capital costs include all initial costs incurred up to plant start-up

b) Operating costs after start-up of plant include direct operating costs and fixed costs

c) Financial sustainability

2.4.6 Legal Issues

In general, legalities do not affect sewerage projects except land acquisition issues which require tact, patience and perseverance.

CHAPTER 3

MATERIALS AND METHODS

CHARACTERIZATION OF UNTREATED SEWAGE AND TREATED EFFLUENT

3.1 Introduction

Pollution in its broadest sense includes all changes that curtail natural utility and exert deleterious effect on life. Degradation of water quality is the unfavourable alteration of the physical, chemical and biological properties of water that prevents domestic, commercial, industrial, agricultural, recreational and other beneficial uses of water. Sewage and sewage effluents are the major sources of water pollution. The growing environmental pollution needs for decontaminating waste water result in the study of characterization of waste water, especially domestic sewage. In the past, domestic waste water treatment was mainly confined to organic carbon removal. Recently, increasing pollution in the waste water leads to developing and implementing new treatment techniques to control nitrogen and other priority pollutants.

3.2 Literature Review

Physical characteristic of waste water:

Odour: It depends on the substances which arouse human receptor cells on coming in contact with them. Pure water doesn't produce odour or taste sensations. Thus waste water which contains toxic substances has pungent smell which makes it easy to distinguish. Odour is recognized as a quality factor affecting acceptability of drinking water.

Taste: The sense of taste result mainly from chemical stimulation of sensory nerve endings in tongue. Fundamental sensations of taste are, by convention more than by research evidence, salt, sweet, bitter, and sour.

Colour: Colour in water results from the presence of natural metallic ions such as Fe or Mg, humus and peat materials, planktons and weeds. It is removed to make water suitable for general and industrial applications. After turbidity is removed the apparent colour and that due to suspended matter is found out.

Total solids: It refers to matters suspended or dissolved in water and waste water. Solids affect the water or effluent quality adversely in a number of ways. Water with highly dissolved solids are not palatable and may cause physiological reaction in transient consumer.

A limit of 500 mg dissolved solids/L is desirable for drinking waters. Evaporation method is used to separate total solids and their weight is found out.

Turbidity: Clarity of water is important in producing products destined for human consumption and in many manufacturing uses. It is caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. The standard method for determination of turbidity has been based on the Jackson candle turbidity meter and Nephlometer.

Chemical characteristic of waste water:

Chemical characteristics of water state the presence of metals their treatment, the determination of inorganic non-metallic constituents and the determination of organic constituents. Chemical characteristics include pH value, chloride content, conductivity, acidity, alkalinity, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand.

Biological characteristic of waste water:

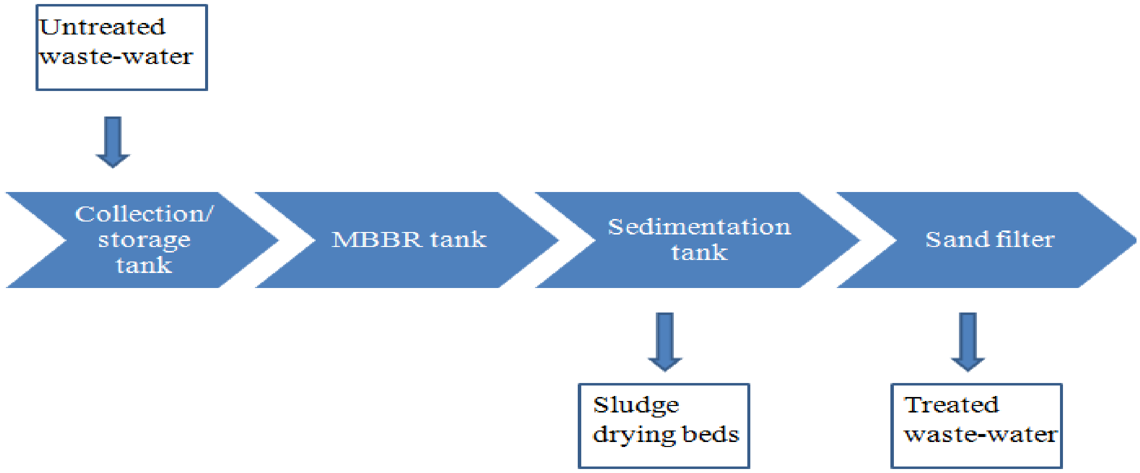
Water quality has a key role in deciding the abundance, species composition, stability, productivity and physiological condition of indigenous populations of aquatic communities. Their existence is an expression of the quality of the water. Biological methods used for evaluating water quality include the collection, counting and identification of aquatic organisms. Most microorganisms known to microbiologists can be found in domestic wastewater like Bacteria, Protozoa, Viruses, and Algae.

Planktons, Periphyton, Macro-phyton, Macro-invertebrates, Fish, Amphibians and Aquatic reptiles are the biotic group of interdependent organism.

3.3 Study Area:

Achievement of a safe and healthful workplace is the responsibility of an organization, the people residing in the place and the workers who are given the charge to protect the environment. Waste disposal and minimization and pollution prevention should be the preferred approach. Stringent penalties for the improper disposal of wastes should be adopted. The untreated waste water sample is collected from collection or storage tank and the sample after treatment is collected from the effluent coming from sand filter at Rajiv Gandhi National Law University Patiala.

fig 3.1: Layout of treatment plant :



3.4 Analysis techniques (table 3.1)

S.No	Parameter	Process
1	pH value	Electrometric method
2	Turbidity	Nephelometric Turbidity meter
3	Electrical conductivity	Electrical conductivity Meter
4	Acidity	Volumetric titration by Standard sodium hydroxide (0.02N).
5	Alkalinity	Volumetric titration by Sulphuric acid (0.02 N)
6	Chlorides	Volumetric titration by silver nitrate solution (Mohr's method)
7	Total solids	Evaporation method
8	Dissolved Oxygen	Volumetric titration by sodium thiosulfate solution (N/50) (Winkler's method)
9	COD	Volumetric titration
10	BOD	Volumetric titration

3.4.1 Measurement of pH value

Electrometric method of pH determination:

It is determined through a instrument by electrolysis and dissociation of H+ and OH- radical, and the milivolts generated give on scale either by movement of analog pointer or digital recording. Knowing pH value is a very important parameter for the analysis of wastewater and its treatment. Certain chemicals and biological processes work only at a particular pH.

Apparatus:

1.pH-strips (papers),

2.pH meter,

3.thermometer

Reagents:

1)Distilled water

2)Standard buffer solutions: Standard buffer solutions having pH values of 4.0 and 9.2 are readily available. Otherwise, they can be prepared easily by dissolving 1 pH tablet of each buffer in distilled water and make up to 100 ml gives a standard solution of pH 4.0 and 9.2.

Procedure:

(i) Switch on the pH meter for 15 minutes.

(ii) After washing and wiping the pH electrode and the temperature probe dip it in a solution of pH 4.0 buffer. Change knob from standby to pH.

(iii With the CAL knob set the pH value to 4.0

(iv) With a pH 9.2 buffer, set the pH value to 9.2 using the SLOPE knob.

(v) Repeat steps 2-3 till the pH meter is standardized with respect to both pH 4.0 and 9.2

(vi)Take the pH values of the different water samples with the pH meter.

3.4.2 Measurement of turbidity

Principle:

When light is passed through a sample having suspended particles some of the light is scattered by the particles. The scattering of the light is generally proportional to the turbidity. The turbidity of sample is thus measured from the amount of light scattered by the sample taking a reference with standard turbidity suspension.

Apparatus:

1.Nephelometric Turbidity meter

2.Sample tubes

Procedure:

1.Switch on Nephelometeric turbidity meter and wait for few minutes till it warms up.

2.Set the instrument at 100 on the scale with a 40 NTU standard suspension. In this case every division on the scale will be equal to 0.4 NTU turbidity.

3.Shake thoroughly the sample and keep it for sometime to eliminate the air bubbles.

4.Take sample in Nephelometer sample tube and put the sample in sample chamber and find out the value on the scale.

5.Dilute the sample with turbidity free water and again read the turbidity.

3.4.3 **Measurement of electrical conductivity**

Principle**:**

The electrical conductivity is a total parameter for dissolved, dissociated substances. Its value depends on the concentration and degrees of dissociation of the ions as well as the temperature and migration velocity of the ions in the electric field.

Apparatus: Conductivity Meter, Beakers, Thermometer.

Reagents: 0.1N KCl

Procedure:

1.Switch on the conductivity meter for 15 minutes.

2.Take out the conductivity cell dipped in distilled water, wash it with distilled water and wipe it dry with a tissue paper.

3.Calibrate the cell with standard 0.1N KCl solution of conductivity 14.12 mmhos at 30°C.

4.Take out the conductivity cell, wash it thoroughly with distilled water and wipe it dry.

5.Dip the cell into the sample solution, swirl the solution and wait upto 1 minute for a steady reading.

6.Note down the instrument reading and also temperature by a thermometer.

3.4.4 Measurement of acidity

Principle:

The mineral acids present in the sample which are contributing mineral acidity can be calculated by titrating or neutralizing samples with strong base NaOH to pH 4.3. The CO2 and bicarbonates (carbonic acid) present and contribute CO2 acidity in the sample can be neutralized completely by continuing the titration to pH 8.2

Apparatus:

1.Burette,

2.pipettes,

3.conical flask.

Reagent Required:

1.Standard sodium hydroxide (0.02N).

2.phenolphthalein indicator

3.Methyl orange indicator

4.Sodium thiosulfate (0.1N)

5.Carbon dioxide free distilled water.

Procedure:

1.Pipette out 100 ml of the given water sample into a conical flask.

2.Add 1 drop of 0.1N sodium thiosulfate solution to destroy any residual chlorine.

3.Add 2 drops of methyl orange indicator. The sample turns pink.

4.Titrate against 0.02N standard sodium hydroxide solution until pink color changes to yellow.

5.Note down the volume of the NaOH added (V1).

6.Take another conical flask containing 100 ml of water sample, add 2 drops of phenolphthalein.

7.Proceed with titration until the sample turns pink.

8.Note down the total volume of NaOH added (V2).

3.4.5 Measurement of alkalinity

Principle:

Alkalinity can be obtained by neutralizing OH-, CO3¬--- and HCO3- with standard H2SO4. Titration to pH 8.3 or decolourization of phenolphthalein indicator will show complete neutralization of OH- and ½ of CO3 -, while to pH 4.4 or sharp change from yellow to pink of methyl orange indicator will indicate total alkalinity i.e. OH , CO3---, and HCO3-.

Apparatus:

1. Burette 2. Pipettes 3. Conical flask

Reagents:

1.Standard sulphuric acid (0.02 N)

2.Phenolphthalein indicator

3.Methyl Orange indicator

4.Carbon dioxide free distilled water

5.Sodium thiosulfate (0.1 N) (Optional)

Procedure:

1.Take 100 ml of the given water sample in a conical flask.

2.Add one drop of 0.1 N sodium thiosulfate solutions to remove the free residual chlorine if present.

3.Add 2 drops of phenolphthalein indicator. The sample turns pink.

4.Run down 0.02 N standard sulphuric acid till the solution turns to colorless.

5.Note down the volume of H_2SO_4 added (V1).

6.Add 2 drops of methyl orange indicator the sample turns to yellow.

7.Resume titration till the color of the solution turns to pink.

8.Note down the total volume of H_2SO_4 added (V2).

3.4.6 Measurement of chloride content

Principle:

The Mohr method for the determination of chloride in water is based upon the fact that in solution containing chloride and chromate, silver reacts with all the chloride and precipitates before the reaction with chromate begins. The appearance of the brick-red colour of the silver chromate precipitate is the end-point of the titration.

Apparatus:

Burette, pipette and conical flask.

Reagents:

1.Chloride free distilled water.

2.Potassium chromate (K_2CrO_4) colour indicator

3.Standard silver nitrate solution (0.0141 N)

4.Standard sodium chloride solution (0.0141 N)

Procedure:

1.Take 100 ml of sample in conical flask.

2.Adjust the pH between 7.0 and 8.0 either with sulphuric acid or sodium hydroxide solution.

3.Add 1 ml of potassium chromate indicator to get light yellow colour.

4.Titrate with standard silver nitrate solution till the colour changes from yellow to brick-red.

5. Note the volume of silver nitrate added (A).

6.For better accuracy, titrate 100 ml of distilled water in the same way after adding 1 ml of potassium chromate indicator to establish reagent blank.

7.Note the volume of silver nitrate added for distilled water (B).

3.4.7 Measurement of total solids

Principle:

The sample is evaporated in a weighed dish on a steam-bath and is dried to a constant mass in an oven either at 103-105°C or 179-181°C. Total residue is calculated from increase in mass.

Apparatus:

•Evaporating Dish

•Steam-Bath

•Drying Oven

•Desiccator

•Analytical Balance

Procedure:

1.The clean evaporating dish is heated to 180°C for 1 hour. It is cooled, desiccated, weighed and stored in desiccator until it is ready.

2.The volume of the sample is selected which has residue between 25 and 250mg, preferably between 190 and 200 mg. This volume may be found out from values of specific conductance. If a measurable residue has to be obtained successive aliquots of sample can be added to the sample dish.

3.This volume is pipetted to a weighed evaporating dish placed on a steam-bath. A drying oven can be used to perform evaporation. To prevent oiling and splattering of the sample the temperature should be lowered to around 98°C. The dish is taken to an oven at 103-105°C, or 179-181°C and dried to constant mass, after complete evaporation of water from the residue. It is done till the difference in the successive weighing is less than 0.5 mg. To eliminate necessity of checking for constant mass drying for a long duration (usually 1 to 2 hours) is done. The time for drying to constant mass with a given type of sample when a number of samples of nearly same type are to be analyzed can be determined by trial.

4.The dish is weighed as soon as it has cooled. Residue is avoided to stay for long time as some residues are hygroscopic and may absorb water from desiccant which may not be absolutely dry.

3.4.8 Measurement of Dissolved Oxygen

Principle:

The principle involved in the determination of DO is to bring about the oxidation of potassium iodide to iodine with the dissolved oxygen present in the water sample after adding MnSO4, KOH & KI, and the basic manganic oxide formed acts as an oxygen carrier to enable the dissolved oxygen to take part in the reaction.

Theory:

Determination of Dissolved Oxygen (DO) is important for drinking water. It is the indication of purity of water. DO is needed for living organisms to maintain their biological processes. If DO is less than the required limit, (6 to 7 mg/l) it is the indication of pollution due to sewage or industrial waste. DO test is used to control the amount of oxygen in boiler feed water to prevent corrosion. DO test helps to assess raw water quality and to keep a check on stream pollution.

Oxygen is poorly soluble in water. The solubility of DO decreases with increase in concentration of salt at 1 atm pressure. The solubility of oxygen of air in fresh water with low solid concentration varies from 14.5 mg/l at 0°C to about 7.5 mg/l at 30°C. Iodometric (Winkler's method) are used for determining DO in water.

Apparatus

BOD bottles (capacity 300 ml), burette and pipettes

Reagents required:

1.Standard sodium thio-sulfate solution (N/50);

2.Potassium permanganate solution (N/10),

3.Potassium oxalate solution (2%);

4.Manganous sulfate solution (4.8%);

5.Alkaline potassium iodide;

6.Freshly prepared starch solution;

7.concentrated sulfuric acid

Procedure:

1.Take a glass stopered bottle of 300 ml capacity and fill it completely with water sample.

2.Add 0.9 ml conc. H_2SO_4 and 0.2 ml (4drops) $KMnO_4$ solution with the help of a pipette. The tip of pipette should dip below the liquid surface. Stopper the bottle and mix the contents of the bottle by inverting it a few times. If the permanganate color is not discharged within 5 minutes, add additional amount of $KMnO_4$.

3.Add 0.5 ml of potassium oxalate solution, stopper and mix well. Add additional amount of oxalate solution if the permanganate color is not discharged in 10 minutes.

4.Now add 2 ml of $MnSO_4$ solution followed by 3 ml of alkaline KI solution. Stopper and shake and allow the precipitate to settle.

5.Now add 1 ml of conc. H_2SO_4 solution and mix until the precipitate is completely dissolved.

6.Measure 102.2 ml of this solution with a measuring cylinder in to a conical flask and titrate slowly against N/50 hypo solution.

7.When the color of the solution is very light yellowish add 2 ml of freshly prepared starch solution and continue the titration to the disappearance of the blue color and note down the volume of hypo used.

8.Repeat the titration to get at least three readings and note down the volume of hypo used.

3.4.9 Measurement of Chemical Oxygen Demand

Principle:

The organic matter present in sample gets oxidized completely by $K_2Cr_2O_7$ in the presence of H_2SO_4 to produce CO_2 and H_2O. The excess $K_2Cr_2O_7$ remaining after the reaction is titrated with $Fe(NH_4)_2(SO_4)_2$. The dichromate consumed gives the O_2 required to oxidation of the organic matter.

Reagents:

1.Standard potassium dichromate 0.25 N

2.Sulphuric acid with reagent (Conc. H_2SO_4 + Ag_2SO_4)

3.Standard ferrous ammonium sulphate 0.1 N

4.Ferroin indicator

5.Mercuric sulphate

Procedure:

1.Place 0.4 gm of $HgSO_4$ in the reflux flask.

2.Add 20 ml of sample (or an aliquot diluted to 20 ml).

3.10 ml of more concentrated dichromate solution are placed into flask together with glass beeds.

4.Add slowly 30 ml of H_2SO_4 containing Ag_2SO_4 and mix thoroughly.

5.Connect the flask to condenser. Mix the contents thoroughly before heating. Improper mixing results in bumping and the sample may be blown out.

6.Reflux for a minimum period of 2 hours. Cool and wash down the condenser with distilled water.

7.Dilute the sample to make up 150 ml and cool.

8.Titrate excess $K_2Cr_2O_7$ with 0.1 N $Fe(NH_4)_2 SO_4$ using ferroin indicator, Sharp colour change from blue green to wine red indicates the end point.

9.Reflux the blank in the same manner using distilled water instead of sample.

3.4.10 Measurement Of Biochemical oxygen demand (BOD)

Principle:

The biochemical oxygen demand (BOD) test is based mainly on the classification of biological activity of a substance. A procedure measures the dissolved oxygen consumed by micro-organisms while capable of taking and oxidizing the organic matter under aerobic conditions. The standard test condition lets in incubating the sample in an air tight bottle, in dark at a required temperature for specific time.

Apparatus:

i)Incubation Bottles: The bottle has capacity of 300 ml. It has narrow neck with even mouth and has ground glass stoppers. New bottles are cleaned with 5 N hydrochloric acid or sulphuric acid and rinsed with distilled water. In normal use, bottles once used for Winkler's procedure should only be rinsed with tap water followed by distilled water. During incubation water is added to the flared mouth of the bottle time to time, to ensure proper sealing.

ii)Air Incubator: Air incubation with thermostatically controlled 27°C +- 1°C. Light is avoided to prevent possibility of photosynthetic production of oxygen.

Procedure:

After taking water in incubation bottles, 4 gm of NaOH is kept at the neck of the bottle. A magnetic stirrer is retained inside the bottle. The magnetic stirrer continuously revolves inside the bottle. Special caps attached with an electronic meter keep the bottle air tight. The instrument directly records BOD reading at every 24 hour. After that the bottles are preserved in the incubators for days as per need of study. The same procedure follows for BOD 3 days and BOD 5 days.

3.5 Results and Significance

3.5.1 Physical Characteristics(Table 3.2)

S.NO	PARAMETER	UNTREATED WASTE-WATER	TREATED WASTE-WATER	PERMISSIBLE LIMIT FOR TREATED WATER	SIGNIFICANCE
1	Color	Greyish-black	colorless	colorless	It is important from aesthetic and psychological point of view
2	Odor	Musky	Odorless	Odorless	Offensive odors can lead to loss in appetite, nausea, vomiting, etc.
3	Turbidity	46 NTU	11 NTU	≤10 NTU	Increased turbidity degrades water quality. Water treatment costs increases.
4	Total solids	1000 mg/l	200 mg/l	<2100 mg/l	High conc. of solids about 3000 mg/l produce distress in livestock. High amount of solids may lead to scaling in boilers, corrosion.
5	Total Suspended Solids	600 mg/l	160 mg/l	<500 mg/l	High conc. is aesthetically displeasing. Suspended solids may include disease causing organisms

6	Total Dissolved Solids	400 mg/l	40 mg/l	<100 mg/l	It is used extensively in the analysis of industrial waste to determine the need for and design of plain settling tanks and in plants employing biological treatment processes.

3.5.2 Chemical Characteristics(Table 3.3)

S.NO	PARAMETER	UNTREATED WASTE-WATER	TREATED WASTE-WATER	PERMISSIBLE LIMIT FOR TREATED WATER	SIGNIFICANCE
1	pH value	6.5	7.7	5.5-9.0	Can affect how chemicals dissolve in water. Treatment methods depend on proper pH value of wastewater.
2	Conductivity (mmhos/cm)	0.633	0.55	0.55-0.9	EC measurements are the basis to evaluate the performance of many process plants. Estimates amount of total dissolved minerals (ions).
3	Acidity (mg/l)	102	47	Upto 50 mg/l	Interferes in treatment of water, corrodes pipes, Acidity due to free CO_2 is less harmful

					than waters containing mineral acidity
4	Alkalinity (mg/l)	250	240	200-600 mg/l	Highly alkaline water are usually unpalatable and consumer acceptance decreases.
5	Chlorides (mg/l)	100	90	Upto 250 mg/l for drinking purposes	Chlorides are also corrosive and impart permanent hardness to water
6	Dissolved Oxygen(mg/l)	0	1.2	4	DO test is necessary for all aerobic biological waste-water treatment processes to control the rate of aeration.
7	COD(mg/l)	400	150	-	COD test is widely used in the place of BOD in the operation of treatment facilities. The ratio of BOD to COD is useful to assess the amenability of waste for biological treatment.
8	BOD(mg/l)	250	5	3-5	BOD test gives an idea of the biodegradability of any sample and strength of the waste

CHAPTER 4

DESIGN OF SEWERS AND APPURTENANCES

4.1 General

Major role of a sewer system can be listed as follows:

- Improvement in the environment by removing the sewage as it originates
- Preventing inundation of low lying areas that may be otherwise caused by not sewering
- Prevention of vector propagation by sluggish sewage stagnations
- Avoiding cross connections with fresh water sources by seepage
- Avoiding sewer impacts on groundwater quality by infiltration of soil water into sewers

4.2 Design Period

The length of time up to which the capacity of a sewer will be adequate is referred to as the design period. In fixing a period of design, consideration must be given for the useful life of structures and equipment employed, taking into account obsolescence as well as wear and tear. Because the flow is largely a function of population served, population density and water consumption, lateral and sub main sewers are usually designed for peak flows of the population at saturation density as set forth in the Master Plan. Trunk sewers, interceptors, and outfalls are difficult and uneconomical to be enlarged or duplicated and hence are designed for longer design periods.

4.3 Per Capita Sewage Flow

The entire spent water of a community should normally contribute to the total flow in a sanitary sewer. However, the observed Dry Weather Flow quantities usually are slightly less than the per capita water consumption, since some water is lost in evaporation, seepage into ground, leakage etc. In arid regions, mean sewage flows may be as little as 40% of water consumption and in well developed areas, flows may be as high as 90%

Table4.1: Institutional needs for potable water

S.No	Institutions	Water Supply(litres)
1	Hospital including laundry and beds exceeding 100	450 per bed
2	Hospital including laundry and beds not exceeding 100	340 per bed
3	Lodging houses / hotels	180 per bed
4	Hostels	135 lpcd
5	Nurses homes and medical quarters	135 lpcd
6	Boarding schools/colleges	135 lpcd
7	Restaurants	70 per seat
8	Airports and Seaports	70 lpcd
9	Train and Bus stations	70 lpcd
10	Train and Bus stations, alighting and boarding persons	15 lpcd
11	Day schools/colleges	45 lpcd
12	Offices	45 lpcd
13	Factories, duty staff	45 lpcd
14	Cinema, concert halls and theatres	15 lpcd

(Source: CPHEEO Manual, 2012)

Table4.2 : 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	2.00

(Source: CPHEEO Manual, 2012)

4.4 Infiltration

Estimate of flow in sanitary sewers may include certain flows due to infiltration of groundwater through joints. Since sewers are designed for peak discharges, allowances for groundwater infiltration for the worst condition in the area should be made as in Table 3.

Table4.3: Ground water infiltration

	Minimum	**Maximum**
Litres/ha/day	5,000	50,000
Litres/km/day	500	5,000
Litres/day/manhole	250	500

(Source: CPHEEO Manual, 2012)

Once the flow is estimated as per the above Table, the design infiltration value shall be limited to a maximum of 10% of the design value of sewage flow.

4.5 Types of collection system

These are separate sewers, combined sewers, pressurized sewers and vacuum sewers.

4.5.1 Separate Sewers

These sewers receive domestic sewage and such industrial wastes pre-treated to the discharge standards as per the Environment Protection Rules 1986 and given the consent to discharge into sewers by the local pollution control administration.

4.5.2 Combined Sewers

These sewers receive storm water in addition and have some advantages in locations of intermittent rainfall almost throughout the year and with a terrain permitting gravitated collection and obviously being confined to a very small region as a whole. As otherwise, in regions of seasonal rainfall like in monsoons, the combined system will have serious problems in achieving self cleansing velocities during dry seasons and necessitating complicated egg shaped sewers etc. to sustain velocities at such times plus the treatment plant to be designed to manage strong sewage in dry season and dilute sewage in monsoon season as also the hydraulics there for.

4.6 Materials of sewers

- Brick
- Concrete

- Stoneware or Vitrified Clay
- Asbestos Cement
- Cast Iron
- Steel
- Ductile Iron Pipes
- Non-Metallic Non-Concrete Synthetic Material Pipes

4.7 Shape and size of sewers

a) In general circular sewer sections are ideal from load bearing point of view in public roads and as the hydraulic properties are better for varying flows.

b)For large flows, the egg shaped sections are superior for both load transmission and velocity at minimum flows plus ability to flush out sediments in the bottom V portion when peak flow arises. These are normally of RCC either cast in situ or pre cast as also brickwork, though brickwork has its challenges of quality assessment and quality control.

c) Box conduits are also possible provided the inner corners are chamfered and the bottom finished as corvettes instead of flat floor.

The minimum diameter in public roads shall be 150 mm and that for house sewer connections to public sewers shall be 100 mm.

4.8 Flow in Circular Sewers

4.8.1 Minimum Velocity for Preventing Sedimentation

Velocity required to transport material in sewers is mainly dependent on the particle size and specific weight and slightly dependent on conduit shape and depth of flow. The specific gravity of grit is usually in the range of 2.4 to 2.65.

Table4.4 : Design velocities to be ensured in gravity sewers

S.NO	**Criteria**	**Value**
1	Minimum velocity at initial peak flow	0.6 m/s
2	Minimum velocity at ultimate peak flow	0.8 m/s
3	Maximum velocity	3 m/s

(Source: CPHEEO Manual, 2012)

4.8.2 Manning's Formula

$V = [(1/n)]*[R^{2/3} * S^{1/2}]$

$Q = A*V$

where,

Q : Discharge in l/s

S : Slope of hydraulic gradient

D : Internal dia of pipe line in mm

R : Hydraulic radius in m

V : Velocity in m/s

n : Manning's coefficient of roughness as in Table 5

Table4.5: Manning's friction co-efficient n for stated materials

Type of Material	**n**
Salt glazed stone ware pipe Good 0.012	0.012
Salt glazed stone ware pipe Fair	0.015
Cement concrete pipes and masonry with cement mortar plaster Good	0.013
Cement concrete pipes and masonry with cement mortar plaster Fair	0.015
FRP	0.010
HDPE / UPVC	0.010
CI with cement mortar lining	0.010
DI with cement mortar lining	0.010

(Source: CPHEEO Manual, 2012)

4.8.3 Design Depth of Flow

The sewers shall not run full as otherwise the pressure will rise above or fall below the atmospheric pressure and condition of open channel flow will cease to exist. Also from consideration of ventilation sewers should not be designed to run full. In case of circular sewers, the Manning's formula reveals that:

The velocity at 0.8 depth of flow is 1.14 times the velocity at full depth of flow.

The discharge at 0.8 depth of flow is 0.98 times the discharge at full depth of flow. Accordingly, the maximum depth of flow in design shall be limited to 0.8 of the diameter at ultimate peak flow.

4.8.4 Slope of Sewer

Table 4.6 Minimum slopes of sanitary sewers

Sewer Size (mm)	Minimum slope(%)	1 in
150	0.6	170
200	0.40	250
250	0.28	360
300	0.22	450
375	0.15	670
450	0.12	830
≥525	0.10	1000

(Source: CPHEEO Manual, 2012)

4.9 Sewer Appurtenances

These are those structures of the sewerage system which are constructed at suitable interval and other locations along a sewer line, to assist in efficient operation and maintenance of the system.

4.9.1 Manholes

A manhole is an opening by which a man may enter a sewer for inspection, cleaning and other maintenance and fitted with a removable cover to withstand traffic loads in sewers. Having designed the sewer system, the manholes are first constructed in identified reaches before the sewers are laid. The diameters of circular manholes for stated depths of sewers are in Table 7.

Table 4.7: Diameters of circular manholes for stated depths of sewers

S.No.	Range of Depths	Internal Diameter
1	above 0.90 m and up to 1.65 m	0.9 m
2	2 above 1.65 m and up to 2.30 m, 1200 mm	1.2 m
3	3 above 2.30 m and up to 9.0 m	1.5 m
4	4 above 9.0 m and up to 14.0 m	1.8 m

(Source: CPHEEO Manual, 2012)

Table 4.8: Recommended spacing of manholes

Size of sewer	Recommended spacing on straight reaches
Dia. up to 0.3 m	45 m
Dia. up to 0.6 m	75 m
Dia. up to 0.9 m	90 m
Dia. up to 1.2 m	120 m
Dia. up to 1.5 m	250 m
Dia. greater than 1.5 m	300 m

(Source: CPHEEO Manual, 2012)

4.9.2 Flushing Tanks

It is device or arrangement which holds water and then throws it into the sewer for the purpose of flushing it. It can be operated either manually or automatically. Sewer laid on flat gradients may not produce self-cleansing velocity and may get blocked frequently. They can be laid with of help of such flushing tanks. Apart from this, flushing tanks are also provided near the dead end of sewers. The quantity of water added in one flush is about 1600 litres. Flushing tanks should have sufficient capacity to hold water temporarily, to serve required purpose. Generally, the capacity of flushing tank is kept equal to one tenth of the cubical contents of the sewer line served by it. The automatic systems which are operated by mechanical units get often corroded by the sewer gases and do not generally function satisfactorily and hence are not recommended.

4.9.3 Grease and oil traps

These are specially built chambers on the sewers to exclude grease and oil from sewage before they enter the sewer line. Such traps are located near those sources, such as automobile repair workshops, garages, kitchens of hotels, industries, which contribute grease and oil in their waste waters.

Presence of Oil and Grease in sewers cause following problems:

- Grease and Oil entering sewer lines stick to interior surface of sewer conduit and become hard causing obstruction of flow.
- Increase possibilities of explosion.
- Floating matter have tendency to stick to the sides of sewer.
- Difficulties in the treatment of wastewater.
- Prevents oxygen to penetrate – aerobic bacteria will not survive.

4.10 Calculations

4.10.1 Estimation of sewerage generation in RGNUL(Table 4.9)

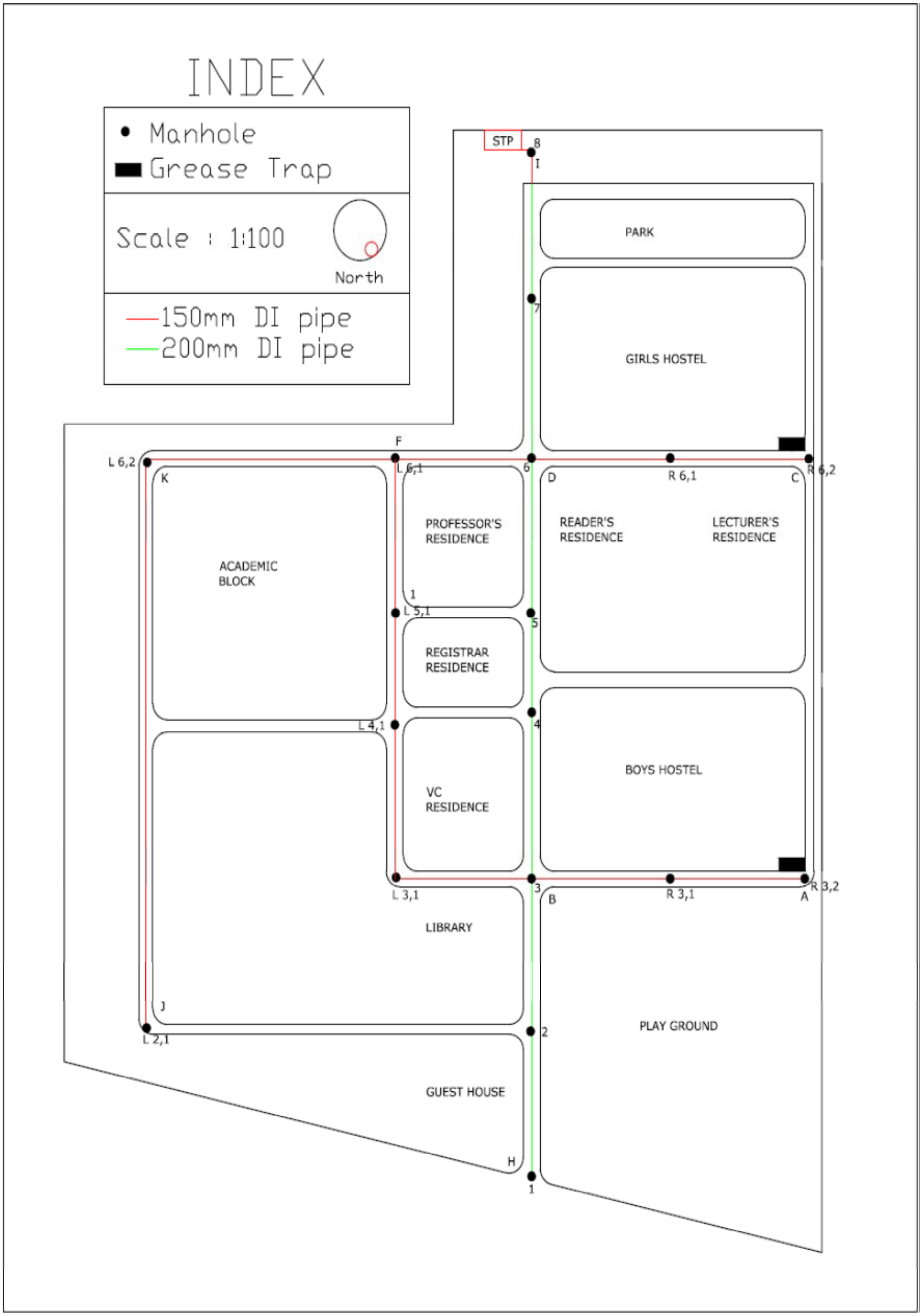
	WATER CONSUMPTION ANALYSIS			
BUILDINGS	WATER CONSUMPTION (lpcd)	NO. OF RESIDENTS	TOTAL CONSUMPTION (lpd)	SEWAGE (@ 90%) lpd
1. Academic block	45	400	18000	16200
2.Hostel				
a, Boys	135	648	87480	78732
b, Girls	135	512	69120	62208
3.Residencies				
a, Professor's	200	24	4800	4320
b, Reader's	200	48	9600	8640
c,Lecturers	200	96	19200	17280
d,Registrar's	200	4	800	720
e,Vice-Chancellor	200	4	800	720
4.Guest house	180	40	7200	6480
5.Library	45	100	4500	4050
6.Dining hall				
a, Boys	70	300	21000	18900
b, Girls	70	200	14000	12600
7.Faclity club	15	50	750	675
		TOTAL	257250	231525

4.10.2 Estimation of diameter of sewer(Table 4.10)

S.NO	PIPE	LENGTH (m)	DISCHARGE (m^3/s)	PEAK DISCHARGE (Q) (m^3/s)	INFILTRATION (m^3/s)	TOTAL (m^3/s)
1	A-B	185	0.00113	0.00339	0.000729	0.004119
2	C-D	185	0.00117	0.00351	0.000087	0.003597
3	E-F	235	0.00031	0.00093	0.00003	0.00096
4	F-D	80	0.00031	0.00093	0.00003	0.00096
5	H-I	560	0.00268	0.00804	0.000846	0.008886

S.No	**PIPE**	**N**	**SLOPE**	**SLOPE ½**	**A**	**p**	**R**	**D (in m)**	**D TAKEN (in mm)**	**VELOCITY (V) (in m/s)**
1	A-B	0.01	1/190	0.0725	0.674 D^2	2.22 D	0.304 D	0.094	150	1.159
2	C-D	0.01	1/190	0.0725	0.674 D^2	2.22 D	0.304 D	0.090	150	1.121
3	E-F	0.01	1/190	0.0725	0.674 D^2	2.22 D	0.304 D	0.054	150	0.805
4	F-D	0.01	1/190	0.0725	0.674 D^2	2.22 D	0.304 D	0.054	150	0.805
5	H-I	0.01	1/250	0.0632	0.674 D^2	2.22 D	0.304 D	0.133	200	1.267

Design of sewer network for RGNLU (Fig. 4.1)



4.10.3 Details of measurement and calculation of quantities for sewers(Table 4.11)

Item no.	Particulars of items of works	No.	Length(m)	Breadth(m)	Depth(m)	Quantity	unit
1	Earthwork in excavation	1	1660	0.6	0.75	747	cu m
2	Timbering	1	1660	0.6		996	sq m
3	Backfill	1	1660	0.6	0.4	398.4	cu m
4	Labour						
	Head mason	2	_	_	_	1	no.
	Mason	35	_	_	_	35	no.
	Mazdoor	45	_	_	_	45	no.
5	Materials						
	150 mm DI pipe	pipe of 3m used	1100	_	_	367	no.
	200 mm DI pipe	pipe of 3m used	560	_	_	187	no.
	Lead for joint	3 kg per joint	_	_	_	1662	Kg
	Spun yarn for joint	0.17 kg per joint	_	_	_	94.18	Kg
	Fuel wood for joint	5kg per joint	_	_	_	2770	Kg

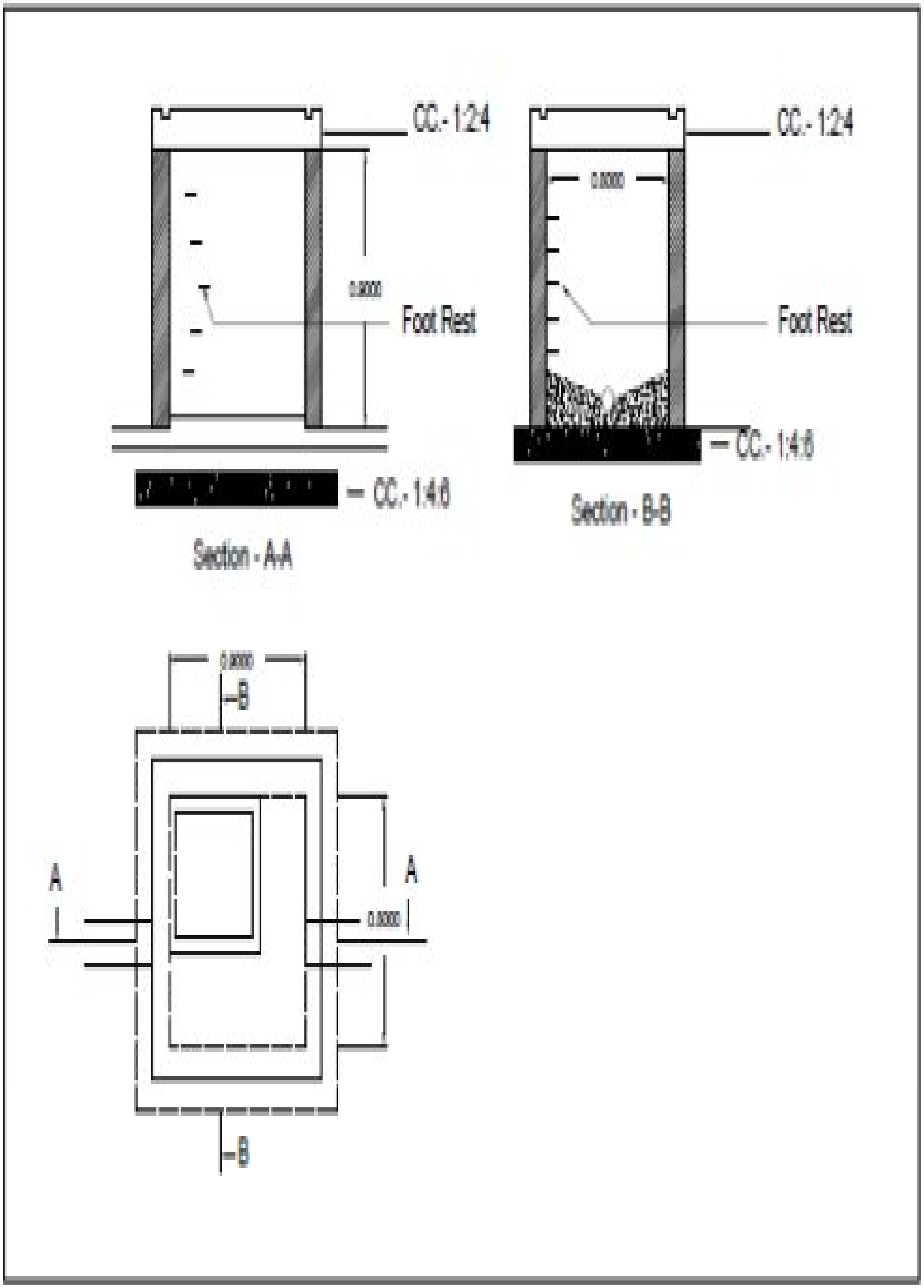
	Kerosene oil for joint	1.3 litre per joint	_	_	_	720.2	litre

4.10.4 Abstract Of Estimated Cost for sewers(Table 4.12)

Item no.	Name of items and details of works	Quantity	Unit	Rate in Rs.	Per	Amount in Rs.
1	Earthwork in excavation	747	cu m	300	/ cu m	224100
2	Timbering	996	sq m	107	/ sq m	106572
3	Backfill	398.4	cu m	101	/ cu m	40238.4
4	Labour					
	Head mason	2	no.	400	/ no.	800
	Mason	35	no.	350	/ no.	12250
	Mazdoor	45	no.	300	/ no.	13500
5	Materials					
	150 mm DI pipe	367	no.	3600	/ no.	1321200
	200 mm DI pipe	187	no.	4950	/ no.	925650
	Lead for joint	1662	Kg	140	/ kg	232680
	Spun yarn for joint	94.18	Kg	40	/ kg	3767.2
	Fuel wood for joint	2770	Kg	5	/ kg	13850
	Kerosene oil for joint	720.2	litre	45	/ litre	32409

					Total	2927016.6
	Additional 5% for contingencies & workcharged establishment					146350.83
					Grand Total	3073367.43

Design of Manholes (Fig. 4.2)



4.10.5 Details of measurement and calculation of quantities for manholes(Table 4.13)

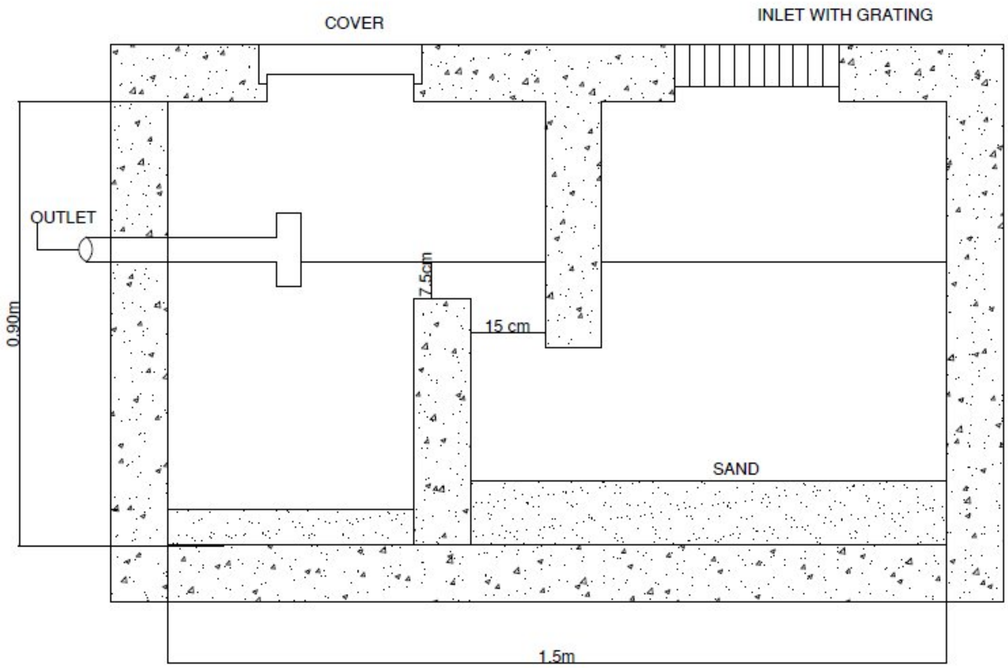
Item no.	Particulars of items of works	No.	Length(m)	Breadth(m)	Depth(m)	Quantity	Unit
1	Earthwork in excavation	1	0.9	0.8	0.9	0.648	cu m
2	C.C 1:4:6 with brick ballast	1	0.9	0.8	0.2	0.144	cu m
3	Brickwork in 1:4 cement mortar						
	wall 1	2	0.9	0.115	0.9	0.1863	cu m
	wall 2	2	0.8	0.115	0.9	0.1656	cu m
					total	0.3519	cu m
4	Cement pointing						
	wall 1	2	0.9		0.9	1.62	sq m
	wall 2	2	0.8		0.9	1.44	sq m
					total	3.06	sq m
5	R.C.C slab	1	0.9	0.8	0.12	0.0864	cu m
	deduct manhole cover	1	0.6	0.5	0.1	0.03	cu m
					total	0.0564	cu m
6	CI manhole cover	1	_	_	_	1	Nos
7	Iron foot steps	5	_	_	_	5	Nos

4.10.6 Abstract Of Estimated Cost for manholes(Table 4.14)

Item no.	Name of items and details of works	Quantity	Unit	Rate in Rs.	Per	Amount in Rs.
1	Earthwork in excavation	0.648	cu m	350	/ cu m	226.8
2	C.C 1:4:6 with brick ballast	0.144	cu m	300	/ cu m	43.2
3	Brickwork in 1:4 cement mortar	0.3519	cu m	345	/ cu m	121.4055
4	Cement pointing	3.06	sq m	192	/ sq m	587.52
5	R.C.C slab	0.0564	cu m	675	/ cu m	38.07
6	CI manhole cover	1	Nos	600	/ no.	600
7	Iron foot steps	5	Nos	42	/ no.	210

					TOTAL	1826.9955
	Additional 5% for contingencies & workcharged establishment					91.349775
					Grand Total	1918.345275
			No. of manholes = 18			
			Total cost	34530.21	Rs.	

Design of Oil and Grease Trap (Fig. 4.3)



CHAPTER 5

DESIGN OF STORM WATER DRAINS

5.1 GENERAL

If storm water is mixed with sewage flow, large sewers will be required. Also, the hydraulic performance of such combined sewers will not be satisfactory. Hence it is frequently preferred to carry the storm water through storm water drains. This is generally accomplished by providing surface drains.

Preferred to carry both sullage as well as rain water from houses and streets. Normally laid along on either side of the streets facing boundary walls of houses and buildings. They require frequent cleaning as bigger size particles float in due to difficulty in ensuring proper self-cleansing velocity. They carry gravity discharge.

5.2 Requirements for efficient working of storm drains

- Smooth inner surface
- Have sufficient carrying capacity and have reasonable free board
- Should be laid on a grade to achieve self-cleansing velocity during DWF
- Structurally safe and stable
- All its joints should be properly and neatly finished
- Sufficient resistance to corrosion

5.3 Estimation of Storm Runoff

Storm runoff is that portion of the precipitation which drains over the ground surface. Estimation of such runoff reaching the storm sewers therefore is dependent on intensity and duration of precipitation, characteristics of the tributary area and the time required for such flow to reach the sewer. The design of storm water sewers begins with an estimate of the rate and volume of surface runoff. When rain falls on a given catchments, a part of the precipitation is intercepted by the vegetation cover which mostly evaporates, some part hits the soil and some of it percolates down below and the rest flows on ground surface. Estimation of such runoff reaching the storm sewers is dependent on intensity and duration of precipitation, characteristics of the tributary area and time required for such flow to reach the sewer. More the intensity of rain, the higher will be the peak runoff rate.

5.4 Rational Method

It is most commonly used for design of storm drains. It takes into account the following three factors :

- Catchment area
- Impermeability Factor
- Intensity of rainfall

The formula can be expressed as:

Q=K*A*I*Ri

where,

Q = Runoff in m^3/hr

K =constant = (1/360)

A = A = impervious area

Ri= Intensity of rainfall in mm per hour

I= Kuchling's Impermeability Factors

5.4.1 Catchment area

The catchment area served by a given storm water sewer can be found directly from the map. Since the factor I depends upon the type of surface , the catchment areas of different types of surfaces should be found separately.

5.4.2 Impermeability factor

The storm water flow depends upon the imperviousness of the surface over which rainfall takes place.

Table 5.1: Kuchling's Impermeability Factors

S.NO	**Type of surface**	**Factor I**
1	Water tight roof surface	0.7 to 0.95
2	Asphaltic pavement in good order	0.85 to 0.90
3	Stone, brick and wood block pavements	0.75 to 0.85
4	Same as above, with open joints	0.5 to 0.7
5	Inferior block pavements	0.4 to 0.5
6	Macadamized roadways	0.25 to 0.6
7	Gravel roadways and walks	0.15 to 0.3
8	Unpaved surfaces, rail yards and vacant lots	0.1 to 0.3
9	Parks, gardens, lawns and meadows	0.05 to 0.25
10	Wooded area or forest land	0.1 to 0.2
11	Most densely populated part of city	0.7 to 0.9

(Source:Waste Water Engg , BC Punmia)

5.4.3 Intensity of Rainfall

The value of factor Ri can be worked out from the rainfall records of the area. However R also depends upon frequency and duration of the storm.

$R_i = (25.4 * a) / (t + b)$

where,

Ri = Intensity of rainfall in mm per hour

t = duration of storm in minutes

a,b = constants

Table 5.2 Duration of storm

Duration of storm	Constant a	Constant b
5 to 20 minutes	30	10
20 to 100 minutes	40	20

(Source:Waste Water Engg , BC Punmia)

5.5 Common shapes of drains

- Rectangular
- Trapezoidal
- Semi - circular
- U - shaped
- V - shaped

5.6 Permissible velocities in drains

Table 5.3 Permissible velocities in drains

Type of Soil/Surface	**Max. Permissible Velocity (m/sec)**
Unlined Drains	
Rock and Gravel	1.5
Murram, Hard Soil etc.	1.0-1.1
Sandy Loam, Black Cotton Soil	0.6-0.9
Very Light Loose soil to avg. sandy soil	0.3-0.6
Ordinary Soils	0.6-0.9
Lined Drains	
Stone Pitched	1.5
Burnt clay tile lined	1.8
Cement Concrete Lined	2.0-2.5

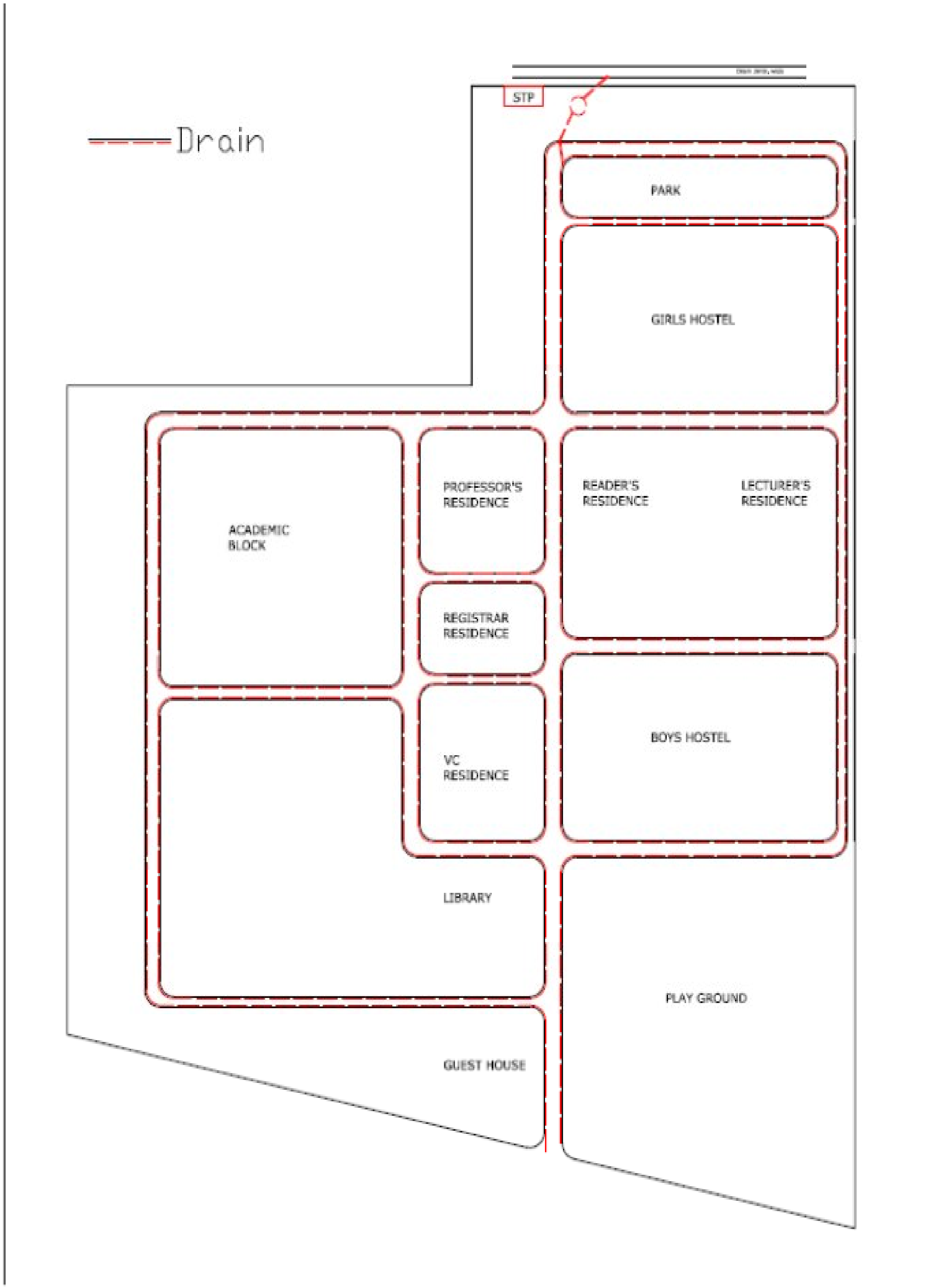
(Source:Waste Water Engg , BC Punmia)

5.7 Calculations

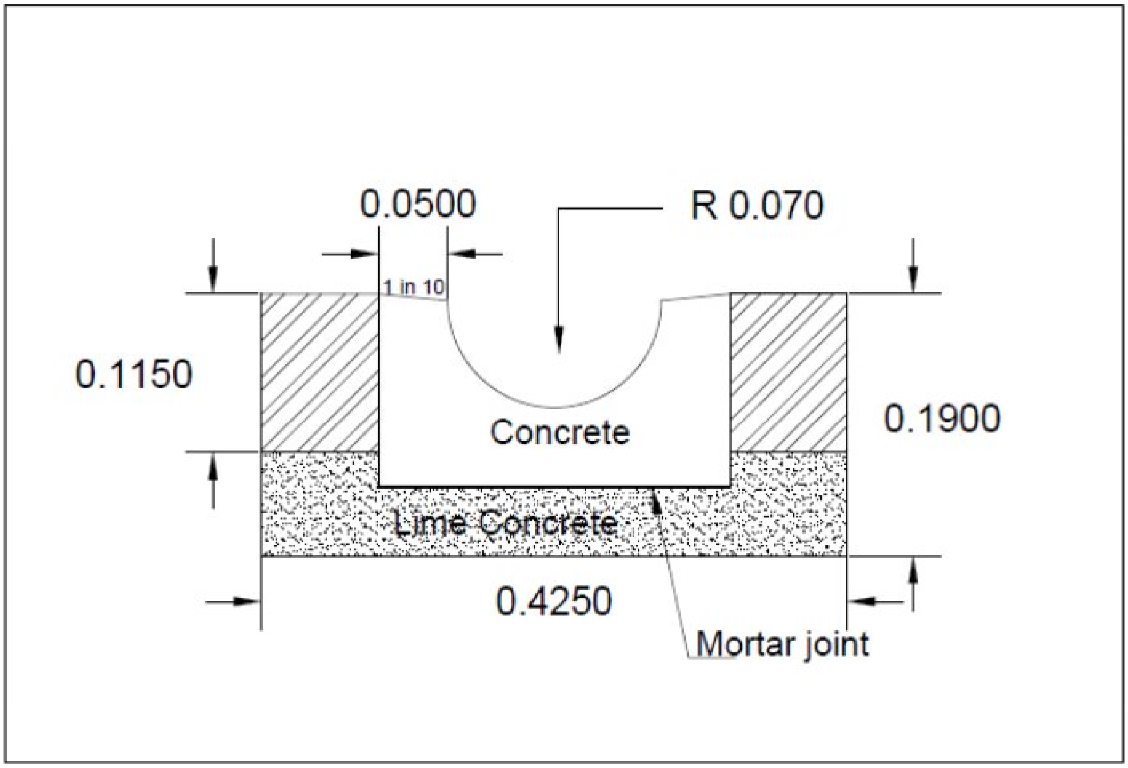
5.7.1 Estimation of Storm Runoff for RGNLU(Table 5.4)

S.NO.	TYPE OF LAND	AREA (hectares)	I	Ai	Ri (mm/hr)	Q (m^3/s)
1	Ground	3.52	0.3	1.05	14.5	0.042
2	Boys Hostel	1.85	0.7	1.29	14.5	0.052
3	Residencies	1.82	0.7	1.27	14.5	0.051
4	Girls Hostel	1.82	0.7	1.27	14.5	0.051
5	Park	0.74	0.25	0.18	14.5	0.007
6	Guest House	0.425	0.7	0.29	14.5	0.011
7	Library	0.51	0.7	0.35	14.5	0.014
8	Residencies	1.65	0.7	1.15	14.5	0.046
9	Facility Club	0.2	0.7	0.14	14.5	0.005
10	Academic Block	2.32	0.7	1.62	14.5	0.065

Design of storm drains (Fig. 5.1)



Storm Drain Section (Fig. 5.2)



5.8 Cost Estimation

5.8.1 Details of measurement and calculation of quantities(Table 5.5)

Item no.	Particulars of items of works	No.	Length(m)	Breadth(m)	Depth(m)	Quantity (cu m)
1	Earthwork in excavation	1	5700	0.425	0.19	460.275
2	Brickwork in 1:6 cement mortar	2	5700	0.085	0.115	111.435
3	Foundation in 1:7:20 C.C or lime concrete	1	5700	0.425	0.075	181.6875
4	1:2:4 Cement concrete	1	5700	0.255	0.115	167.1525
	Deduct :					
	semi circle portion	1	5700	1/2*∏	0.07^2	43.8723
	Total					123.2802

5.8.2 Abstract Of Estimated Cost (Table 5.6)

Item no.	Name of items and details of works	Quantity	Unit	Rate in Rs.	Per	Amount in Rs.
1	Earthwork in excavation	460.275	cu m	350	/ cu m	161096.25
2	Brickwork in 1:6 cement mortar	111.435	cu m	320	/ cu m	35659.2
3	Foundation in 1:7:20 C.C or lime concrete	181.6875	cu m	300	/ cu m	54506.25
4	1:2:4 Cement concrete	123.2802	cu m	450	/ cu m	55476.09
					TOTAL	306737.79
	Additional 5% for contingencies					15336.8895
					Grand Total	322074.6795

CHAPTER 6

DESIGN OF SEWAGE TREATMENT PLANT

6.1 General

Sewage is 99 % water carrying domestic wastes originating in kitchen, bathing, laundry, urine and night soil. A portion of the wastes go into solution and the rest are partly in colloidal suspension and true suspension. Besides these salts are also added to the water by the human usage from salts used in cooking, body washings, laundry and urine. Besides sewage also contains water borne pathogenic organisms of cholera, jaundice, typhoid, dysentery and gastroenteritis which originate from the night soil of already infected persons.

6.2 Factors affecting design of Sewage treatment plant (STP)

1.**Engineering factors** : Design period, population, expected sewage flow, Topography of area, sites available for plant, on site disposal facilities.

2.**Environment factors**: Surface water, coastal water quality where wastewater has to be disposed. Odour which affect land values .Meeting public health considerations.

3.**Process considerations** :Waste water flow and characteristics, degree of treatment required, performance characteristics. Availability of land ,power equipments and staff for maintenance .

4.**Cost considerations** : Capital costs for land, construction, equipments etc. operating costs for staff, chemicals, fuels and electricity, maintenance and repairs, etc.

6.3 Fluidised Aerobic Bio-Reactor (FAB)

Fluidised Aerobic Bio-Reactor (FAB) as the name indicates consists of floating media of cylindrical shapes and different sizes. As compared to conventional technologies FAB reactors are compact, energy efficient and user friendly.

Basic principle: Flock forming organisms form clusters or attach to available surfaces. The FAB media provide very large surface area (450 M^2 per M^3 volume) which:

- Increase the specific volumetric capacity of activated sludge tanks.
- Controls biomass activity

- Reduces operating cost

6.3.1 Advantages using FAB Reactor:

- Significant reduction in space requirement due to high surface area & loading rate of FAB media.
- Reduced power and operating costs
- No sludge recycle required hence no sludge recycle pumps.
- FAB Reactor is best suitable when designing a new waste water treatment plant, where space is constraint .
- Upgrading of existing waste water treatment plants.
- Operate plants in low temperature areas.

6.4 Working of FAB Technology

The fluidized aerobic bioreactor includes a tank in any shape filled up with small carrier elements. The elements are specially developed materials of controlled density such that they can be fluidised using an aeration device. A biofilm develops on the elements, which move along with the effluent in the reactor. The movement within the reactor is generated by providing aeration with the help of diffusers placed at the bottom of the reactor. The thin biofilm on the elements enables the bacteria to act upon the biodegradable matter in the effluent and reduce BOD/COD content in the presence of oxygen from the air that is used for fluidisation.

6.5 Design Calculations

6.5.1 Estimation of size of STP required for RGNLU(Table 6.1)

	VALUE	UNITS	REMARKS
1. Rate of water supply			
Hostel , residencies	135	Lpd	
Day visitors	15	Lpd	
2. Rate of sewage generation	80%		of water supply
3. Estimate sewage generation			
Phase 1			
a) hostel 500 students[500*135*80%]	54000	Lpd	
b) residents 200 [200*135*80%]	21600	Lpd	
c)visitors 250[250*15*80%]	3000	Lpd	
Total	78600	Lpd	
Phase 2			
a) hostel 1000 students[1000*135*80%]	108000	Lpd	
b)visitors 250[250*15*80%]	3000	Lpd	
Total	111000	Lpd	
Grand Total	189600	Lpd	
Design Flow	200000	Lpd	

6.5.2 Design for equalization tank(Table 6.2)

Parameter	Value/Calculation	Remarks
STP quantity	200 kld =200 m³/day	Quantity of sewage to be handled by the STP on daily basis
Hourly average sewage inflow	= 200/24 m3/hr = 8.33 m³/hr	
Equalization tank Volume	= 8.33*6 =50 m³	Tank is designed to hold six hours of average flow
Freeboard	0.3 to 0.5 m	Selected by convention
Water depth in tank	2.0 to 2.5 m	The incoming sewage line is already below ground level, and the entire equalization tank has to be located below this pipe. This puts a constraint on the depth.
Tank area	= 50/2 =25 m²	Area = Volume / Depth Select length and width to suit the site conditions

(Source : The STP guide by Anand S Kodaval)

6.5.3 Design for Bar Screen(Table 6.3)

	VALUE	UNITS	REMARK
DESIGN FOR BAR SCREEN			
for peak flow	20000	Lpd	
Assumption			
Bar inclination	45	Degree	
Bar size	9x50	mm²	
Bar spacing	36	Mm	
Velocity (through screen)	0.8	m/sec	V
Max. rate of flow	0.00023	m³/sec	
Net area of screen	0.00028	m²	
Gross area	0.00036	m²	
Gross area needed	0.00051	m²	
velocity of flow above screen	0.64	m/sec	v
Head loss			
1) when screen clean	0.017	M	
2) when screen clogged	0.157	M	

6.5.4 Design for Sedimentation Tank(Table 6.4)

	VALUE	UNITS	REMARK
DESIGN FOR SEDIMENTATION TANK			
Quantity of water to be treated	200	m^3/day	
Detention Time	2	hours	
Assumption			
Overflow rate	1200	l/hr/m^2	
Quantity of water to be treated(in 2 hrs)	16.666667	m^3	
Velocity (in tank)	0.02	m/min	
Length	2.4	m	
Width	2.8935185	m	
Depth	2.4	m	

(Source:Waste Water Engg , BC Punmia)

6.5.5 Design for Pressure Sand Filter(Table 6.5)

Parameter	Value/Calculation	Remarks
Design throughput flow	200 kld =200 m^3/day	Quantity of sewage to be handled by the STP on daily basis
Design filtration hours	20 hrs (per day)	Allow 4 hours for rest, backwash, etc.
Filtration rate	=200/20 =10 m^3/hr	The filter must be able to handle the clarified water at this rate.
Loading rate on filter	=12m^3/m^2/hr	Empirically taken optimum value, to achieve filtration efficiency at minimum size of filter
Filter cross-sectional area required (min)	=10/12 =0.83 m^2	= (Filtration rate) / (Loading rate)
Diameter of filter (min)	=(0.83*4/∏)½ =1 m	Area of a circle= ∏/4 x Dia2
Height of filter	1.5 - 1.8 m	Selected by convention
Depth of sand layer	0.6 - 0.75 m	Selected by convention

(Source : The STP guide by Anand S Kodaval)

CHAPTER 7

REUSE OF SEWAGE WATER AFTER TREATMENT

7.1 Introduction

In India treated sewage is being used for a variety of applications such as

(a) Farm Forestry,

(b)Horticulture,

(c) Toilet flushing,

(d) Industrial use as in non-human contact cooling towers,

(e)Fish culture

7.2 Practices in India

a) The CMWSSB has been promoting the growth of farm forestry in Chennai from the 1980's and this helps to promote a micro climate in a city environment.

b) The Indian Agricultural Research Institute, Karnal has carried out research work on sewage farming and has recommended an irrigation method for sewage fed tree plantations.

c) The University of Agricultural Sciences, Dharwad, Karnataka has found that sewage could be used in producing vermi compost to be used for tree plantations provided its details with respect to composition of toxic substances are known.

d) Chandigarh is using treated sewage for horticulture needs of its green areas.

e) Delhi has put in place planned reuse of treated sewage for designated institutional centres.

g) In major metropolitan cities like Delhi, Mumbai, Bangalore and Chennai treated grey water is being used for toilet flushing in some of the major condominiums and high rise apartment complexes on a pilot scale.

Table 7.1: Recommended guidelines for treated sewage if it is discharged into surface water

Parameter	MOEF Standards*	Recommended Values (not to exceed)
BOD, mg/l	20	10
SS, mg/l	30	10
T KN, mg/l	100	10
Dissolved P, mg/l	5	2
Faecal Coliforms, MPN / 100 ml	Not specified	230

*Note: General Standards, Environmental Protection Rule, 1986

source : CPHEEO Manual

7.3 GUIDING PRINCIPLES FOR INDIA

Key Principles for agriculture

a) Being an agrarian economy, this is a very compelling use for India, but should never be used for edible crops or plants that produce millets, etc.

b) The use of untreated sewage for whatever form of agriculture leads to a situation where the treated sewage entering another basin from its parental basin creates issues of water rights and as far as possible, inter basin transfer of such reuse are not to be encouraged.

c) Agricultural use being more pertinent in rural settings, local sewage is best treated with stabilization ponds followed by maturation ponds.

d) Rotational crop pattern shall be investigated for an all the year round utilization and designed such that the runoff of treated sewage in summer is minimized.

e) As far as possible, manual direct handling shall be avoided and field channels are better suited as compared to sophisticated drip irrigation etc.

f) Discharge standards for disposal on land is prescribed by the MoEF.

7.4 Water quality ratings

Nature of soil	Crop to be grown	Permissible limit of Electrical Conductivity of water for safe irrigation (micro-mhos/cm)
Deep black soils and alluvial soils having a clay content more than 30%	Semi-Tolerant	1,500
Fairly to moderately well drained soils	Tolerant	2,000
Heavy textured soils having a clay content of 20-30%	Semi-Tolerant	2,000
Soils well drained internally and having good surface drainage system	Tolerant	4,000
Medium textured soils having a clay content of 10-20%	Semi-Tolerant	4,000
Soils very well drained internally and having good surface drainage system	Tolerant	6,000
Light textured soils having a clay content of less than 10%	Semi-Tolerant	6,000
Soils having excellent internal and surface drainage	Tolerant	8,000

source :CPHEEO Manual

Table 7.2 : Recommended treated sewage quality for agricultural purposes

S.No	Parameter	Recommended value (not to exceed)
1	SS	100 mg/l
2	TDS	2100 mg/l
3	PH	5.5-9
4	Temperature(˚C)	5˚C above receiving water
5	Oil & Grease	10 mg/l
6	Minimum Residual Chlorine	1 mg/l
7	BOD	30 mg/l
8	COD	250 mg/l
9	Faecal Coliform	Non-detectable / 100 ml
10	Colour	Colourless
11	Odour	Odourless
12	Turbidity	≤ 2NTU

Source : Source: I S: 10500 of 1991

7.5 Re-Use of Waste Water At RGNLU

The waste water after treatment will be used for landscape irrigation. Planning a proper waste water irrigation system needs attention to various aspects which are :

- Waste water available for irrigation
- Choice of crops
- Land Requirement of farm
- Distribution system
- Other elements of system

7.5.1 The quantity of waste water available at treatment plant.

	WATER CONSUMPTION ANALYSIS			
BUILDINGS	WATER CONSUMPTION (lpcd)	NO. OF RESIDENTS	TOTAL CONSUMPTION (lpd)	SEWAGE (@ 90%) lpd
1. Academic block	45	400	18000	16200
2.Hostel				
a, Boys	135	648	87480	78732
b,Girls	135	512	69120	62208
3.Residencies				
a,Professor's	200	24	4800	4320
b,Reader's	200	48	9600	8640
c,Lecturers	200	96	19200	17280
d,Registrar's	200	4	800	720
e,Vice-Chancellor	200	4	800	720
4.Guest house	180	40	7200	6480
5.Library	45	100	4500	4050
6.Dining hall				

a,Boys	70	300	21000	18900
b,Girls	70	200	14000	12600
7.Faclity club	15	50	750	675
		TOTAL	257250	231525

However, the effective quantity available for irrigation is much less owing to percolation and evaporation losses en route.

Evaporation losses(@ 12 %) = 27,783 lpd

Percolation losses (@ 18 %) = 41,675 lpd

Net water available =1,62,067 lpd

7.5.2 Choice of crops

The choice of crop depends on the region , climate , soil and waste water charaecteristics. The selection generally depends on the agricultural practces and market demands of the area. Here, in our case the treated water is used for landscape irrigation. Therefore, different crops grown are various trees, woodlands, ornamental plants , grass and flowers .

7.5.3 Organic Loading

11.0 to 28.0 kg/ha/day of organic loading in terms of BOD5 is needed to maintain a static organic matter content in the soil that helps to conditions the soil by microorganisms without solid clogging**.** Most solids in wastewater after treatment applied on land are retained in top 5cm or so while dissolved solids flow through.

7.5.4 Utilization of Plant Nutrients

Sewage contains 26-70 mg/1 of nitrogen (N), 9-30 mg/l of Phosphate and 12-40 mg/l or even more of potash. The recommended dosages for N, P and K for majority of field crops are in the ratio of 5:3:2 or 3 respectively. The figures for N, P, and K contents of sewage on the other hand show that sewage is relatively poor in phosphates. Excess potash is not of significance but a relative excess of nitrogen affects crop growth and development. Crops receiving excessive dosage of nitrogen show superfluous vegetative growth and decrease in grain or fruit yield. The phosphate deficit of sewage, therefore, should be made good by supplementing with phosphate fertilizers.

7.5.5 Odour control

Adequate circulation and aeration are necessary for algae and odour control. The ways by which water can be aerated are:

- Fountains : these systems spray water into air
- Air injection : air is blown into water and allowed to bubble to surface.
- Waterfalls and streams : tumbling water over rock or other surfaces not only aerates the water but can be aesthetically pleasing.
- Constructed wetlands : plants such as cattails and willows are effective both at removing toxins and oxygenating the water.

7.5.6 Distribution system

Various types of irrigation systems can be provided for distribution of treated waste water such as surface irrigation, flood irrigation, spray and drip irrigation. Landscape Irrigation using overhead system not only wastes water and energy through evaporation and wind overspray, but also creates vehicular damage risks and irritants caused by surface run-offs. With drip irrigation, the water is applied directly to the plant's root zone, optimizing water usage, eliminating run-offs and enhancing its beauty. In RGNLU drip irrigation system can be used efficiently.

<u>Advantage of Drip Irrigation in Landscape</u>

- **No run-offs and wind over sprays** – unlike overhead irrigation, which is subject to runoffs and wind overspray’s, drip irrigation accurately applies water to the root zone only. This not only means saving water, it may even save from vehicular and pedestrian damage, caused by water spills on the road.

- **Eliminates vandalism** - since the systems are often completely buried and not visible, vandalism is avoided, reducing maintenance costs.

- **Self cleaning and root prevention** –drip irrigation solutions were designed to operate in the toughest environments (even below the ground) without requiring any maintenance or intervention. A combination of unique technologies ensures that the dripper withstands dirt clogging and intrusion of roots. – Unlike overhead irrigation drip irrigation offers precise control and flexibility. Even in a small and narrow area, you can apply different irrigation policies for every type of plant. For example, flower beds can receive a different dosage of water and fertilizers, than the ones applied on grass or trees.

- **Long laterals with a single valve** –drip irrigation solutions are both low pressure and low flow systems. This means that you can deploy very long laterals connected to a single valve and still enjoy uniform irrigation throughout the traffic island. In contrast, overhead irrigation requires splitting the traffic islands into irrigation zones which are connected to multiple water sources, wasting more water and energy and requiring more ongoing maintenance.

fig 7.1 : park before subsurface irrigation

fig 7.2 : Installation of subsurface land irrigation system

fig 7.3 : park after Installation of subsurface land irrigation system

7.6 Components of a drip-irrigation system

7.6.1 Water source

Common water sources for drip irrigation are surface water (pond, river, and creek), groundwater, and potable water . Potable water is of high, constant quality, but is by far the most expensive . Here, the treated water from STP is used .

7.6.2 Pumping system

The role of the pumping system is to move water from the water source to the field through the distribution system. Pumping systems may be classified as electric powered systems, gas/diesel powered systems, and gravity systems.

7.6.3 Distribution system

The role of the distribution system is to convey the water from the source to the field. Distribution systems may be above ground (easily movable) or underground (less likely to be damaged). Pipes are most commonly made of PVC or polyethylene plastics. Aluminium pipes are also available, but are more difficult to customize, cut, and repair.

7.6.4 Drip tape (or drip tube)

The drip-irrigation system delivers water to each plant through a thin polyethylene tape (or tube) with regularly spaced small holes, called emitters. Selection of drip tape should be based on emitter spacing and flow rate. The typical emitter spacing for vegetables is 12 inches, but 8 inches or 4 inches may be acceptable. Dry sections of soil may develop between consecutive emitters when a wider emitter spacing (18 inches) is used on sandy soils.

7.6.5 Injectors

Injectors allow the introduction of fertilizer, chemicals and maintenance products into the irrigation system. The use of an anti-siphoning device (also called backflow-prevention device) when fertilizer, chemicals or any other products are injected into a drip-irrigation system ensure the water always moves from the water source to the field. The devices prevent chemicals in the water from polluting the water source.

7.6.6 Filtration system

Because drip-irrigation water must pass through the emitters, the size of the particles in the water must be smaller than the size of the emitter to prevent clogging. Nearly all manufacturers of drip-irrigation equipment recommend that filters be used.The filtration system removes "large" solid particles in suspension in the water. Different types of filters are used based on the type of particles in the water. Media filters (often containing angular sand) are used with surface water when large amounts of organic matter (live or dead) need to be filtered out. Screen filters or disk filters may be used with groundwater. A 200-mesh screen or equivalent is considered adequate for drip irrigation. When the water contains sand, a sand separator should be used.

7.6.7 System controls

System controls are devices that allow the user to monitor how the drip-irrigation system performs. These controls help ensure the desired amount of water is applied to the crop throughout the growing season.

Pressure regulators, installed in-line with the system, regulate water pressure at a given water flow (Fig.7), thereby helping to protect system components against damaging surges in water pressure.

Water meters monitor and record the amount of water moving through a pipe where the water meter is installed. When a stopwatch is used together with a water meter, it is possible to determine the water flow in the system in terms of gallons-per-minute.

Soil-moisture-measuring devices (such as tensiometers, capacitance probes or Time Domain Reflectometry probes) are used to measure soil moisture in the root zone of the crop.

Factor	Plugging hazard based on level		
	Slight	Moderate	Severe
pH	<7.0	7.0 to 7.5	>7.5
Dissolved solids (mg/L)	<500	500 to 2000	>2000
Manganese (mg/L)	<0.1	0.1 to 0.5	>0.5
Iron (mg/L)	<0.1	0.1 to 0.5	>0.5
Hydrogen sulfide (mg/L)	<0.5	0.5 to 2.0	>2.0
Hardness (mg/L $CaCO_3$)	<150	150 to 300	>300

Table 7.3: Water quality parameter levels of drip-irrigation systems

7.7 Piping

The guidelines for distribution of non-potable include following recommendations:

- Non potable pipe should be buried atleast 1 foot deeper than potable water supply.
- All buried off-site piping in non-potable water system, including service lines, should have embossed lettering , integrally stamped/marked or be installed with warning tape.
- Hose bibs discharging reclaimed water should be secured to prevent any use by public.
- Quick coupler fittings should be such that inter-connection cannot be made between potable and non-potable systems.

7.8 Other elements of system

Collection and disposal of surplus irrigant is very important. It can be of two types :

- the unused irrigant which is surplus to system
- the used irrigant which either flows over the soil or percolates into the soil.

In a properly engineered system, the water surplus to irrigant requirement, can be stored or discharged elsewhere (adjoining river) without causing any environmental hazards . The surplus water thus can also be reused for washing of the road inside the college campus.

7.9 Protection against Health Hazards

- Farms must be separated from residential areas by at least 300 m horizontal distance.
- The staff of farms must be well educated in the sanitary rules on the utilization of sewage for irrigation as well as with personal hygiene.
- All persons working in farms must undergo preventive vaccination against enteric infections and annual medical examination for heliminthoses and be provided treatment if necessary.
- Farms should be provided with adequate space for canteens with proper sanitation, wash-stands and lockers for irrigation implements and protective clothing.
- Cultivation of crops which are eaten raw should be banned.

Conclusion

Sewerage and sewage treatment is a part of public health and sanitation, and according to the Indian Constitution, falls within the purview of the State List. In sewerage system the function of carrying sewage is done through well planned distribution system choosing suitable diameter of pipes as it comprises the major investment in the system. Manning's Formula has been used for estimating the required discharge in each outlet of the sewer pipe network. Rational formula has been used for calculation of storm water discharge. The objective of a sewage collection, treatment and disposal system is to ensure that sewage discharged from communities is properly collected, transported, and treated to the required degree in short, medium, and long-term, and disposed-off / reused without causing any health or environmental problems. The immediate and nuisance-free removal of sewage from its sources of generation, followed by treatment, reuse, or dispersal into the environment in an eco-friendly manner is necessary to protect public health and environment.

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