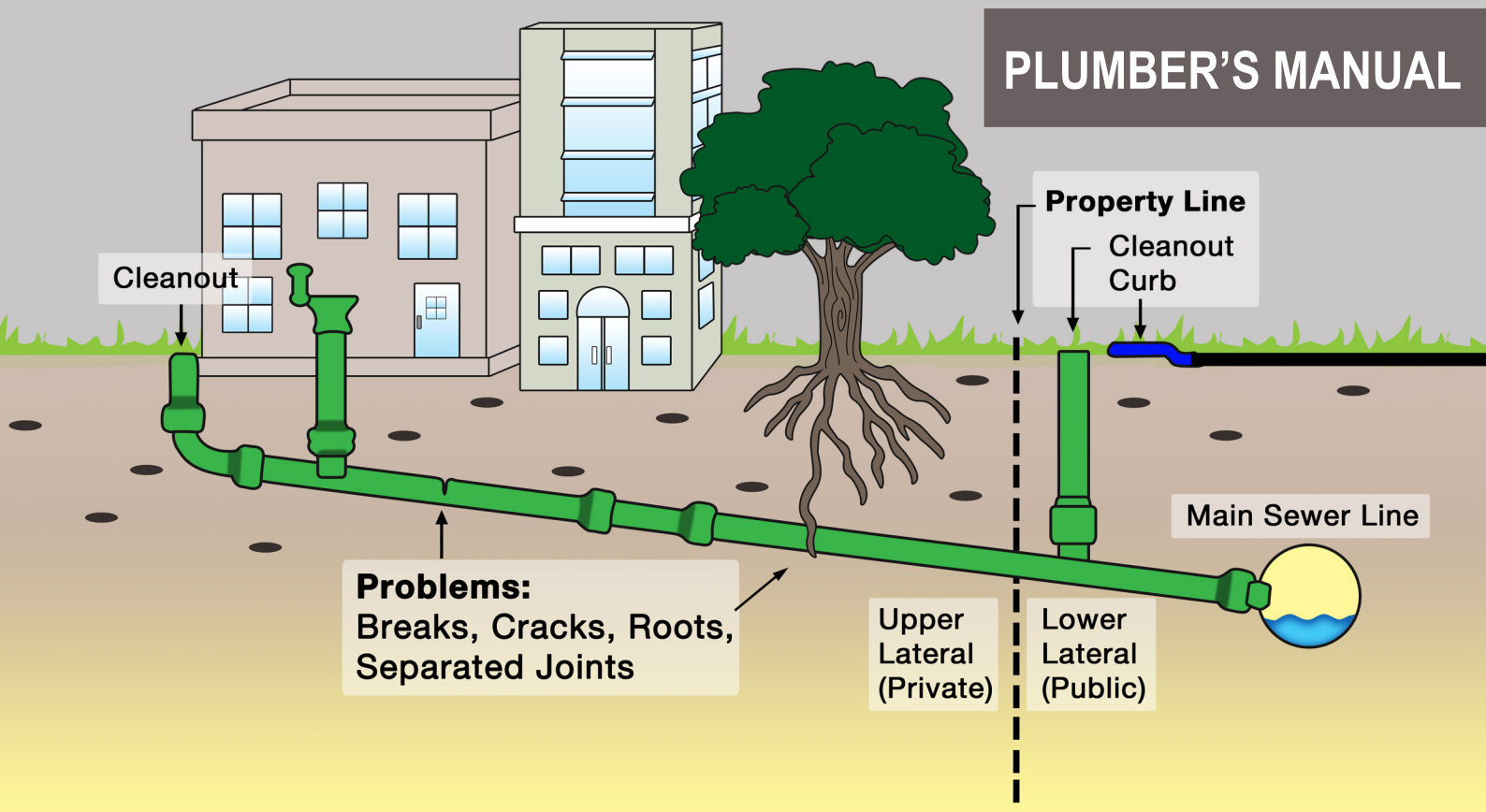


# REFRESHER COURSE FOR **PLUMBERS** ON HOUSEHOLD CONNECTIVITY



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# FOREWORD

India is urbanizing and very soon every second Indian will live in cities. There is an urgent need to build livable cities, providing adequate opportunities and services for all, as clearly stated in the National Urban Sanitation Policy issued by Ministry of Urban Development, Government of India in 2008. The enormous urban growth and transformation requires skills on all levels. Besides of urban planners, managers and engineers there is also a need to strengthen the practical implementation on the ground.



This specifically applies to plumbing, as the rapid transition has put forth serious pressure on civic infrastructure systems for sanitation. Provision of water supply services, household level connectivity to septic tanks and to sewerage systems, improper disposal of wastewater are becoming critical to maintaining health and environment in Indian cities. It is crucial that plumbers understand the concept and design of a city's water supply and sewerage system which will enable them to guide and install proper household connections in the city.

This publication is a training manual for plumbers covering the plumbing aspects for connecting households to the septic tanks or sewerage systems. I hope this manual helps to improve the capacities of the plumbers, whose impacts on overall sanitation in the city is most important.

I would like to thank our partners and my SNUSP team for the efforts undertaken in addressing this important issue.

**Dr. Regina Dube**

**Programme Director – SNUSP  
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# List of Acronyms

ABR	Anaerobic Baffled Reactor	MSL	Mean Sea Level
AC	Asbestos Cement	MSP	Main Soil Pipe
AVB	Atmospheric Vacuum Breaker	MVP	Main Ventilating Pipe
BD	Building Drain	MWP	Main Waste Pipe
BOD	Biochemical Oxygen Demand	NBC	National Building Code
BT	Bath Tub	NRV	Non Return Valve
BVP	Branch Vent Pipes	NUSP	National Urban Sanitation Policy
CI	Cast Iron	OHT	Over Head tank
DI	Ductile Iron	PRV	Pressure Reducing Valve
DWV	Drain, Waste and Vent	PSS	Public Sewerage System
EPDM	Ethylene Propylene Diene Monomer-Rubber	PVB	Pressure vacuum breaker
GDP	Gross domestic product	PVC	Polyvinyl Chloride
GI	Galvanized Iron	RCC	Reinforced Cement Concrete
Gol	Government of India	S	Sink
HDPE	High Density Polyethylene	SBR	Styrene Butadiene Rubber
HRT	Hydraulic Retention Time	SBS	Small Bore System
IC	Inspection Chamber	SITS	Sewered Interceptor Tank Systems
IPC	International Plumbing Code	ST	Septic Tank
IS	Indian Standard	STEDS	Septic Tank Effluent Disposal Scheme
LDPE	Low Density Polyethylene	STP	Sewerage Treatment Plant
LEED	Leadership in Energy & Environmental Design	STS	Secondary Treatment System
lpcd	liters per capita per day	TWL	Top Water Level
lpm	liters per minute	UG	Under Ground
MH	Manhole	UPC	Uniform Plumbing Code
MoUD	Ministry of Urban Development	UPVC	Unplasticized Poly Vinyl Chloride
MS	Mild Steel	WB	Wash Basin
		WC	Water Closet



# Introduction

NUSP reiterates the process of sanitation-related utility management and encourages Urban Local Bodies (ULBs) to regain ownership of the same. However, lack of human resources and capacities to handle problems hamper this process. Therefore, the role of capacity development is crucial in achieving and sustaining 100% sanitation. This can be addressed through training, recruitment of manpower, organisational restructuring and establishment of Standard Operating Procedures.

During the preparation of City Sanitation Plans (CSPs) it was observed that issues relating to household level connectivity to septic tanks and to sewage systems, improper disposal of wastewater, etc. are affecting overall city sanitation. One of the main reason for the above mentioned issues is weak capacities of human resources engaged in these activities. It has been realized that the aspect of household level connectivity to sewerage systems or septic tanks is neglected by residents and workforce involved in this activities due to lack of knowledge/capacities. The ground reality, therefore, calls for strengthening of the capacities of stakeholders engaged in plumbing at municipal level. It is crucial that plumbers understand the concept and design of a city's water supply and sewerage system which will enable them to install proper household connections and understand its impacts on overall sanitation in city. To address the issue of weak capacities in this sector and to bridge the institutional gap GIZ has developed a training module for municipal plumbers focusing on household level connectivity.

## **Objective**

The overall goal is improvement of citywide sanitation, health and environment through introduction of good practices for household level wastewater discharge. The objective of the training module is to help plumbers improve their skills on household level connectivity. The module will also be integrated into existing plumbing training courses.

## **Approach**

The focus was to develop a training module on specific plumbing aspects for connecting households to the septic tanks or sewerage systems. A desk review of existing training manuals and technical specifications was done that includes Indian Standard Codes (IS code), Uniform Plumbing Code India 2011, CPHEEO manual, existing plumbing courses etc. The desk review was followed by an appraisal study in four GIZ supported cities to understand on the ground problems in connectivity issues and incorporate the lessons learned into the training module. Partner training institutes such as Maharashtra Environmental Engineering Research and Training Academy (MEETRA) in Nashik, Maharashtra, Industrial Training Institute, Shimla, Himachal Pradesh, Training division of Kerala Water Authority, Thiruvananthapuram, Kerala, PHED training Division, Raipur, Chhattisgarh were identified for technical support and for review of the content of newly developed plumber training module on time to time.

Test run trainings were organized for municipal plumbers in Shimla, Nashik, Kochi and Raipur for ground testing of the manual and for getting feedback from plumbers working on field. The target group for the test trainings were plumbers registered with Municipal Corporations. Training of trainers programmes were also conducted to train the instructors from various institutes in Himachal Pradesh and Maharashtra.

The training module developed by GIZ-SNUSP is expected to help in reducing the capacity gaps and to be part of on-going plumbing courses or refresher trainings for already certified plumbers.

# About the Manual

## Guide to the trainers

India is witnessing an increase in urbanization, increase to the tune of 31.8% decadal in urban population. According to 2011 census, 81.4% of the total urban households have access to toilet facilities within the premises, 11% defecate in the open and the rest dependent on shared or community toilets. Around a fifth of the households do not have access to drainage net work. More than 37% of the total human excreta generated in urban India is unsafely disposed. This discharge of untreated domestic/municipal waste water has resulted in contamination of 75% of all surface water across India. This imposes significant public health and environmental costs to urban areas that contribute more than 60% of the country's GDP.

Water supply and sanitation in Public Health Engineering have acquired a very important place in the building construction and maintenance field. Development in plumbing engineering, sanitary fixtures and pipes is taking place at a fast pace. New materials and designs are coming in the market every day. The subject gains more importance as more and more vertical rise buildings are being constructed in India. But the personnel involved in the implementation of the sanitary system, especially the plumbing engineers and plumbers, are not well acquainted with modern and systematic steps of working, standards & newer materials and designs, thus resulting in poor hygiene causing pollution in general.

In October 2008, to address the issues of urban sanitation, Ministry of Urban Development, Gol adopted National Urban Sanitation Policy (NUSP). The role of capacity building and training for the plumbing engineers and plumbers is crucial in achieving and sustaining 100% sanitation. Plumbers constitute a major proposition of ground staff and are important as they are crucial work force in implementation, operation and maintenance of water related infrastructure. Hence it is necessary to train the cadre and help them update their knowledge and skills on current practices so that the hygiene and service delivery could be improved.

GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) under its programme on "Advisory support to the NUSP" supports the MoUD, Gol, for implementation of NUSP to achieve and sustain 100% sanitation conforming to the standards. A Module/Hand Book supported by GIZ under the above programme on Plumbing with particular reference to the connectivity of household sewage to the septic tanks or sewerage system is now prepared to deal with basic design and installation procedures in a very simple manner.

The Refresher Course for Plumbers on Household Connectivity to Septic Tanks & Sewerage System is a manual designed to upgrade plumbers' understanding of link between household and plumbing network, provide a step by step instruction, tips, and practical field exercises to drive down the right plumbing approaches.

Even though the scope of plumbing work in this manual is restricted to connecting the building drain to the septic tank or sewerage system, the ultimate aim of the manual is to improve plumbers' understanding of designing and implementing household connectivity to available sewerage system in all environments, including high altitude and high water table areas. This manual also includes additional material for creating sewerage systems for small communities, areas and settlements in a cost effective and innovative manner. Focus is also given on green plumbing concepts and the status of septic tanks when new sewerage connection is given. The manual will refresh theoretical concepts, reinforce right approaches through lab experiments, showcase common mistakes committed by plumbers through field visits, and access their level of understanding through simple class based test and home assignments.

## Who are the target group?

The target group for this training are

- Plumbers who are practicing the trade
- Those aspiring to be plumbers

The minimum qualification is expected to be at the higher secondary level. The manual is designed keeping in mind the fact that the practicing plumbers might or might not have undergone a formal plumbers training course before.

## How the manual was developed?

This manual was compiled by a panel of senior and competent subject matter experts. They conducted desk review of existing technical specifications, undertook field visits to various cities (Kochi, Shimla, Nasik, Pune) to study the ground problems in connectivity issues and discussed with trainers from leading plumbers training institutions to identify gaps/ needs in the plumbers training. The lessons learnt from the field studies and insights gained from the discussion were used to compile the appraisal reports and design the manual. The manual was prepared with details obtained from the suppliers of fixtures and pipes, the plumbing engineers and contractors. The Uniform Plumbing Code-India, various IS codes and available printed manuals and materials from secondary sources were also researched.

Plumbers pilot training was organized in several cities (like Shimla, Nasik, Raipur, & Kochi) to gather feedback on the draft manual. The draft manual was also shared with instructors from Training Institutions in these cities (namely Maharashtra Environmental Engineering Training and Research Academy [MEETRA], ITI College – Shimla, Indian Plumbing Association and Kerala Chamber of Commerce & Industry, Kochi and various municipal corporations) and their feedback were obtained. Subsequently feedback was also obtained from wide range of stakeholders involved in plumbing (Academia, Local government officials, Experts) through Training of Trainers sessions arranged in several cities (namely Shimla, Nashik). The final Plumbers manual was developed integrating the inputs, comments and suggestions obtained from all above mentioned interactions.

## 1. Training details

<b>Name of the Training</b>	Refresher Course for Plumbers on Household Connectivity
<b>Duration</b>	3 days
<b>Target Group</b>	Plumbers Aspiring Plumbers

## 2. Key topics covered

Chapter Name	Duration*	Objective
<b>Chapter 1:</b> Basic concepts of plumbing	120 minutes	To help plumbers understand the bigger Figure of how a sewerage system works at a town / city level and draw the attention to the impact that plumbing has on a city / town's environment, health, and sanitation  To refresh the basic concepts of plumbing including good plumbing practices, cross connections, water conservation and green plumbing concepts
<b>Chapter 2:</b> Overview to public sanitation systems and process	180 minutes	To train plumbers on the right practices to be adopted to connect the drainage system of a house to a Public Sewerage System (PSS)
<b>Chapter 3:</b> Sewerage connections – when new public sewerage network is commissioned	80 minutes	To train plumbers on how to modify old / existing drainage system when a new PSS is introduced
<b>Chapter 4:</b> Connecting building drainage to septic tank and other decentralized systems	180 minutes	To train plumbers on the right practices to be adopted to connect the drainage system of a house to a septic tank and further to an individual disposal system
<b>Chapter 5:</b> Sewerage connections – high altitude and high water table terrain	120 minutes	To train plumbers on the right approaches / special practices and precautions that needs to be followed while connecting the household drainage system to PSS / Septic tank in a high altitude and / or high water table terrain
<b>Chapter 6:</b> Manual scavenging and occupational health & safety	30 minutes	To train plumbers on manual scavenging and occupational health and safety

\* - Duration is only indicative and can be changed based on requirements at different locations



# CHAPTER 1

# Basic Concepts of Plumbing

## Chapter Objective:

The chapter will help refresh a plumber's understanding of:

- Importance of plumbing
- Key plumbing concepts
- Various types of plumbing systems inside a building
- Good plumbing practices, viz,
  - How to avoid cross connections
  - Water conservation techniques
  - General principles of green plumbing

Plumbers need to be aware of these principles while connecting house / building piping systems with public systems (water supply / sewerage). This knowledge will help plumbers adopt right approaches, techniques in connecting house sewerage systems to septic tanks or public sewers.

**Chapter Duration: 120 minutes\***

## SECTION 1: Importance of plumbing

### Plumbing defined

Plumbing, in general, refers to the system as well as the material fixtures and the apparatus used inside a building for supplying water, removing the used water with other liquid and water-borne wastes as well as the connected ventilating system.

In practice it also includes the storm water or roof drainage and exterior system components connecting to a source of water supply or a point of disposal of waste or used water.

The plumber should achieve the best possible plumbing levels to en-

sure the highest health benefits from use of sound plumbing practices.

Any building should be built with an eye for general sanitation and, an effective intelligently planned plumbing. Many buildings have been designed without sufficient regard to these factors and the plumbing has suffered accordingly and the unsatisfactory plumbing causes serious inconveniences to the building users. Protected water is supplied for use and wastewater is collected for carrying outside the building. The possibility of contamination of protected water supply through cross-connections between the piping systems and at plumbing fixtures has to be borne in mind in the plumbing work, failing which, the contamination of protected water supply will pose health risk to the inmates.

An important aspect in plumbing is to look into the structure's sewerage and water supply layouts, which requires the skills and knowledge of a licensed plumber. In the absence of the above, the building will suffer from the following:

#### **Weakened and unstable structure**

When the overall water flow system is not properly laid out, leakage can occur in any part of the construction. When this happens anywhere near the structure's steel foundation, the steel reinforcement can get rusty and eventually give way.

#### **Lack of sanitation**

Badly plotted plumbing can definitely be a threat to the health of the future occupants. Leaks and defective plumbing system, which leads

#### **DID YOU KNOW?**

The three roles a competent plumber must assume are:

1. To design, install and maintain water supply and waste removal systems;
2. To manage health risk and cost associated with plumbing;
3. To help conserve water.

\*duration is only indicative and can be changed based on requirements at different locations

to the growth of moulds and mildews – two major agents that can cause different kinds of illnesses in an enclosed space. Added to this foul smell coming from the clogged toilet will be a threat to the health of the occupants.

### Diminished appeal

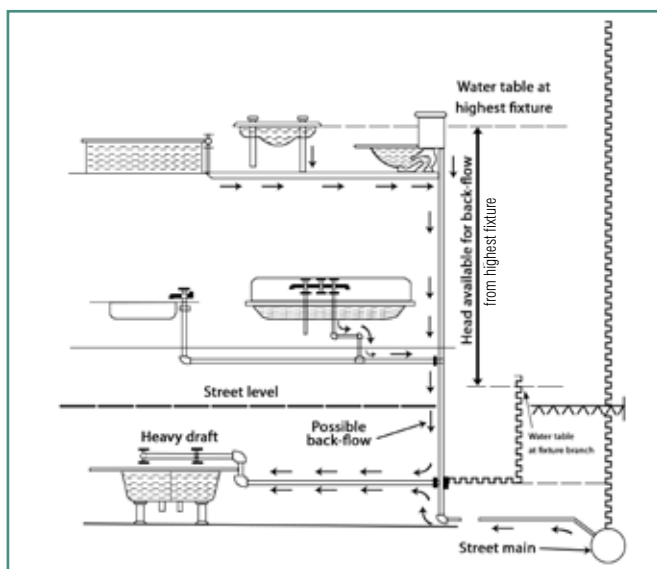
The sight of leaks on the ceilings or moulds on the walls is not only unsanitary; it is definitely a sore to the eyes.

### Noise due to faulty plumbing

Another important factor to be considered is the noise caused due to unsatisfactory plumbing. The serious annoyance and even ill effects on health of residents due to noise caused by the operation of plumbing systems, particularly in the case of apartments, is to be noted.

#### Impact on city sanitation:

The house plumbing is the beginning of the drainage system and the termination of the water distributing system. It is here that a cross connection between the protected water supply system and the waste water disposal system is possible due to bad plumbing. It is therefore necessary that all works relating to plumbing within and outside the premises are properly executed under the supervision of the authorities at all stages.



**Figure 1:** Cross-connection - risk to public health

Due to improper plumbing within the user's plumbing system, when backflow occurs then it is possible to contaminate the public water system. Backflows usually are caused by a backpressure or backsiphonage.

Backsiphonage is the reversal of normal flow in a system caused by negative pressure, vacuum or partial vacuum in the supply piping. This can be created when there is a stoppage of the water supply due to fire fighting, main repairs or main breaks or leaks.

#### Impacts on environment:

Unsatisfactory plumbing in any building may pose concern to the surrounding environment. The following are the few examples:

1. **Contamination of drinking water source** - The effluent sub soil dispersion system should be at least 18 m away from any source of drinking water. If such distance is not maintained, there is every possibility of the drinking water source get polluted.
2. **Disposal of treated effluent** - The effluent from the septic tank/compact sewage treatment plant shall be disposed of by adequate treatment approved by the Authority on the site. It shall be discharged into a natural watercourse or on the surface of the ground. In the case of dilution into a natural stream course, the

quality of the effluent shall confirm the requirements of the Authority controlling the prevention of pollution of streams. In the absence, the local source of water supply gets polluted causing environmental damage.

3. **Indoor Air Pollution due to foul gases** - The waste water from the building should be connected to the drain through a gully trap. The waste water should not be let into the open drain



**Figure 2:** Untreated effluent

or allowed to soak away. Such act will emit foul smell and the air surrounding will get polluted.

4. **Overloading of public sewerage system** - Illegal storm water collections may lead to hydraulic overload of the sewerage system during heavy rainfall events. This may result in contamination of the runoff with excreta flowing in streets and sometimes houses
5. In practice, many septic tanks discharge effluent to the nearest open drain instead of approved way of disposal causing environment damage.

#### Impact on health aspects:

Improper plumbing system in any building can cause health hazard to the people residing in the buildings and society at large. Some of health hazards posed by improper plumbing include

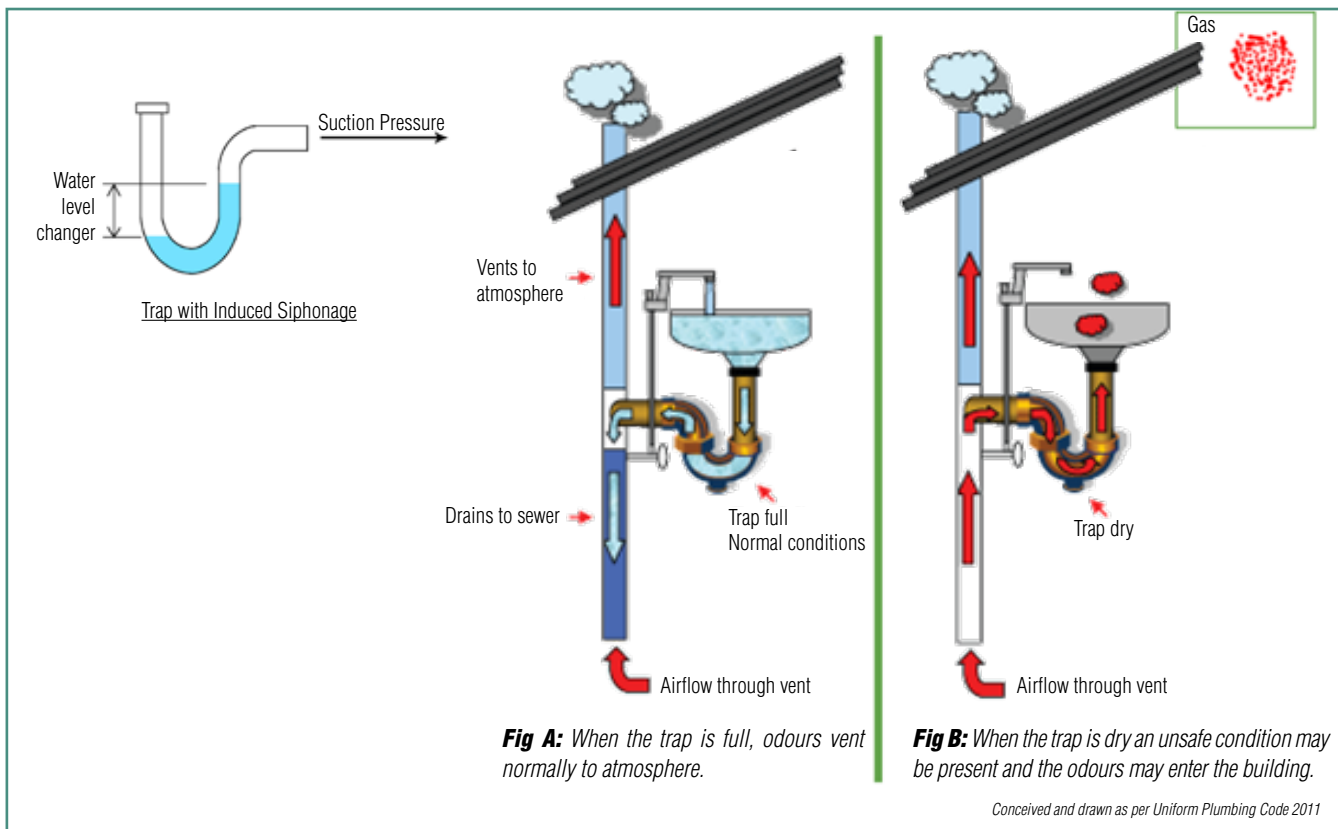
- Release of foul gases – forcing residents to move out of the house
- Release of harmful air borne pathogens – causing respiratory diseases
- Contamination of portable water with impurities and pathogens

This can be countered through

- Use of Traps and Seals
- Avoiding cross connections (see section 3 for more details)
- Regular preventive cleaning and maintenance of Plumbing system.

In any sound plumbing system, each fixture is attached with an essential feature known as trap. The trap is basically the curved section of the drain pipe which maintains a water seal between the pipe and the outside that prevents sewer gases and unpleasant odours from permeating in to the house.

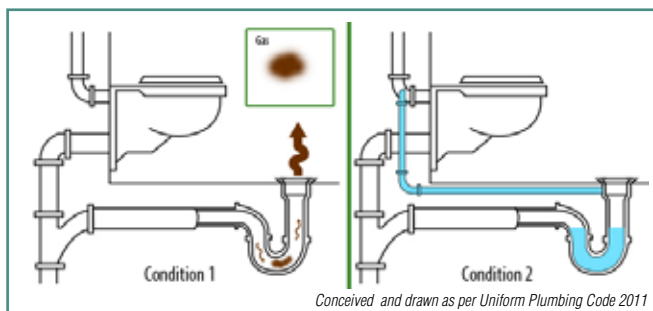
The absence of proper trap and proper seal give room for the entry of sewer gases from the drain in to the house and the prolonged inhalation of sewer gases invite respiratory problems to the people. It may be noted that buildings have been evacuated due to a range of sudden and widespread health complications.



**Figure 3:** Entry of sewer gas in to the building

**Trouble Shooting**

1. Provide an automatic trap primer as shown in Figure 4 below.
2. The traps and trap seal should be inspected periodically and maintained properly



**Figure 4:** Automatic trap primer

Condition 1: Standard traps can dry out, allowing sewer gases to enter the building.

Condition 2: Traps should be designed with automatic primers to prevent entry of gases.

*Other risks:*

Hot water and scalding

- The plumbing system should provide hot water at a safe permissible temperature. Burns from hot tap water can result in severe injuries to young children and the elders. Almost all hot water burns in children occur in the bathroom. The average temperature of hot water systems in India is 55 °C. Water at a higher temperature can inflict a severe burn on a child in less than half a second. In

many industrialized countries, the average hot water temperature is 60 °C which will cause a severe burn in about five seconds.

- While parents can help reduce the risk by checking bath temperatures and by supervising children, the obvious answer is to minimize the risk by reducing the temperature of the water in the hot water system to below 55 °C (but not below 50 °C, which would increase Legionella risk), depending on the specifications of the system that has been installed. An alternative is to install thermostatically controlled mixing valves on the bath taps.

**DID YOU KNOW?**

Any building however costly, without proper plumbing system, is only a skeleton. Proper plumbing alone adds life to the building. Hence proper plumbing system as per the code of practices with the correct specifications of materials like pipes and fixtures should be used to make buildings sustainable.

**FIELD VISIT**

Visit the local river/water body where waste water is being let out to see the environmental impact.  
Visit your municipal waste water disposal plant to understand its functioning

**SECTION 2: Introduction to sewerage system**

**A. Sewage / Drainage:** Refers to waste water generated after cleaning, washing, bathing from kitchen, wash basins, bathrooms, toilets, and urinals from a house. It contains liquid and solid waste materials including human excreta and other house hold waste.



Sewage is of two types:

- **Black water** – Refers to waste water discharged from water closets and urinals. It contains human excreta. The black water is discharged into public sewerage system or a septic tank.

The black water in the septic tank is broken down by bacteria in the septic tank and is partially digested. This black water which undergoes treatment in septic tank is called **Septage**.

Septage is generally split into three parts in a septic tank:

- **Scum** – which floats to the top and is generally where the bacteria live which treat the waste.
- **Effluent** – which is the semi-treated liquid that comprises the majority of the material in the septic tank
- **Sludge** – the solids which collect at the bottom of the tank

#### DID YOU KNOW?

##### *Misuse of the storm drain:*

A storm drain is a pipe or culvert system that collects and carries rainwater from streets, yards, parking lots and rooftops and discharges it untreated into streams and lakes.

Many people believe that storm drains are connected to sanitary sewer systems and that storm water is treated at sewage treatment plants. THIS IS NOT TRUE! Storm water is not treated.

- **Grey water** – Refers to waste water discharged from bathtubs, showers, wash basins, kitchen sink, and washing machine. It does not contain human excreta. This is also called **Sullage**. (Ref: IS 1742 : 1983 - Reaffirmed in 2002)

Some people have the habit of discharging grey water or effluent from the septic tank from their house in to the storm drain without knowing that they are damaging the environment and cause nuisance or injury to health of the people and animals living nearby as the grey water and the effluent from the septic tank contain diseases causing pathogens and bacteria.

Hence the grey water or the effluent should not be let into the storm water drain. It should be treated as per the local rules and disposed off in to the land or water body.

**B. Plumbing system:** Refers to closed system of pipes used for the distribution of water (clean & used) in a building.

This in turn has 2 systems –

- **Potable / clean water system** – Refers to the closed system of pipes which circulates clean water in the building. This water source can be public water supply from corporations / municipalities or private well / tube well.
- **Sewerage system** – Refers to a closed system of pipes which collects waste waters (black / grey) from the house and discharges it into the septic tank / public sewerage system.

**C. Fixtures:** These are bridging elements which connect both the

potable water and sewage system. Care should be taken to avoid contamination of clean water with waste water. This is discussed separately in **section 3** (Cross-connections).

**D. Types of sanitary pipe system:** There are two broad types of sanitary pipe systems used in houses/ buildings

- One Pipe system
- Two Pipe system

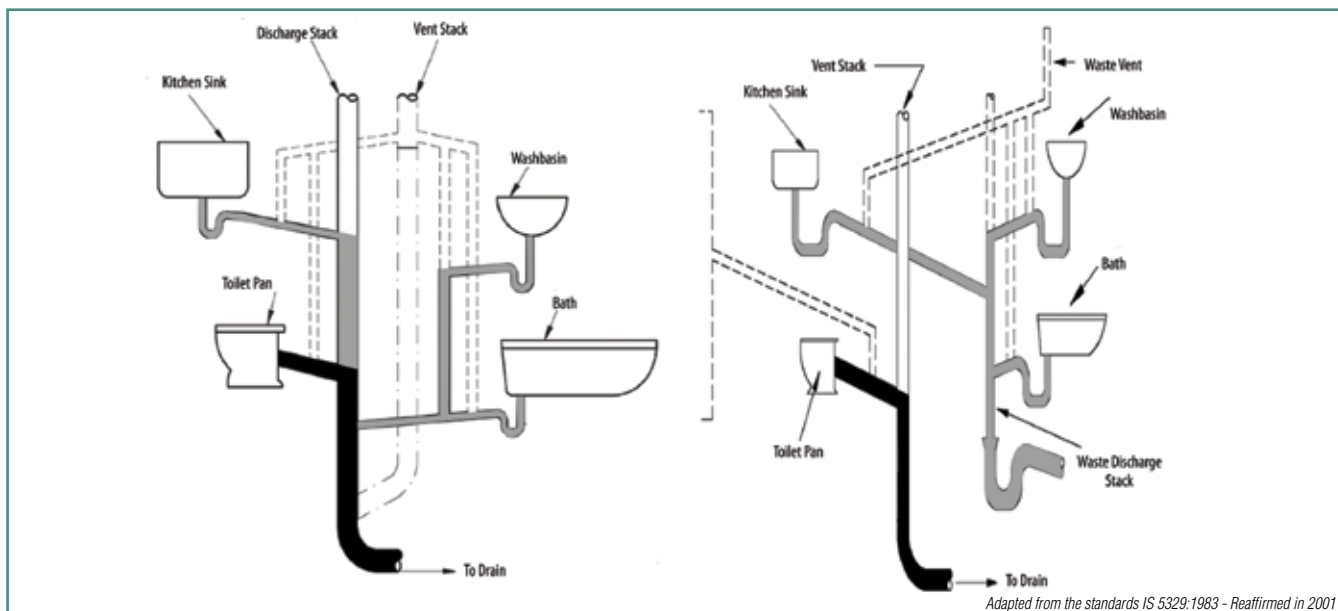
The key differences between the two types of sanitary pipe system are listed in Table 1 below

Parameters	One Pipe System	Two Pipe System
Black & Grey water collection	Collected through one pipe	<ul style="list-style-type: none"> <li>• Collected through two separate pipes</li> </ul>
Black water discharge	Black & Grey water is mixed and connected directly to building drain.	<ul style="list-style-type: none"> <li>• Connected directly to building drain.</li> </ul>
Reuse of grey water	As grey and black water are mixed, water can't be reused with moderate treatment.	<ul style="list-style-type: none"> <li>• As the grey water is collected separately, it can be reused with moderate treatment for gardening, flushing toilets and in cooling towers</li> </ul>
Preferred conditions	Preferred when cost is the driving factor. initial cost of single pipe system is approximately 60% of a double pipe system/s	<ul style="list-style-type: none"> <li>• It is the traditional and recommended system for any house.</li> <li>• Best suited when fittings are scattered and widely separated.</li> </ul>
Ventilating pipe	There is one ventilating pipe which discharges foul gases to the air. All traps of grey / black water appliances are ventilated through this ventilating pipe.	<ul style="list-style-type: none"> <li>• There are two separate ventilating pipes for black and grey water.</li> <li>• All traps of grey / black water appliances are ventilated separately.</li> </ul>
Gully Traps	Not used.	<ul style="list-style-type: none"> <li>• Grey water is connected to building drain through a Gully trap.</li> </ul>

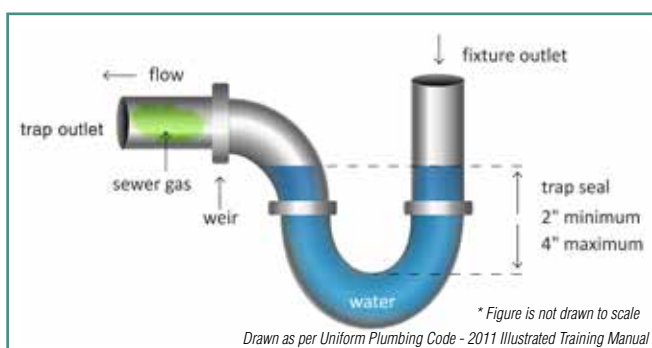
IS 5329 :1983 - Reaffirmed in 2001

**Table 1:** One pipe system vs two pipe system

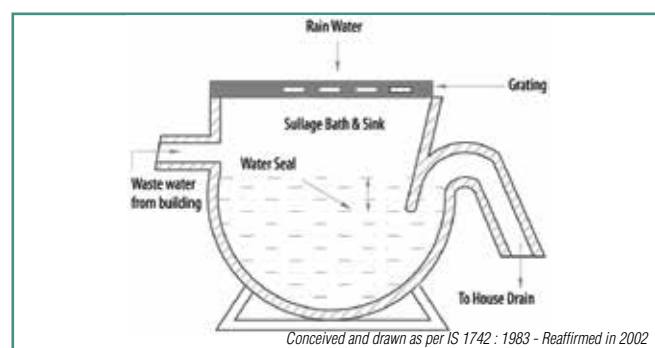
- **Trap seal for sanitary appliances** – Attached to each fixture, either externally or internally, is an essential feature known as trap. The trap is basically the curved section of the drainpipe which maintains water seal between the pipe and the outside that prevents sewer gases and unpleasant odours from permeating in to the house.
- **Gully trap** – This is provided at junctions in the drainage system. There are two entry locations for these types of traps. Waste from bathrooms, kitchen etc. enters through horizontal inlet. Water from floor cleaning or from rain water system enters from top grating screen. These traps provide wider entry to flow, smooth surface, easy cleaning arrangements and deep water seal.
- **Vent pipe system** – The vent pipe or anti-siphonage pipe is installed to provide flow of air to or from a drainage system or to provide circulation of air within such system to protect trap seals from system consists of siphonage and back flow. The system consist of one Main Ventilating Pipe (MVP) to which are connected the Branch Vent Pipes (BVP) of each storey.



**Figure 5:** One pipe system and two pipe system



**Figure 6:** Trap seal for sanitary appliances



**Figure 7:** Gully trap

The main ventilating pipe extended above the building provides a safe outlet of the foul gases in the drain or sewer into the atmosphere.

#### Gully trap in a nutshell

Gully Trap provides wider entry to flow, smooth surface, easy cleaning arrangements and deep water seal.

#### Tips to plumbers on sanitary pipe works in a building (As per IS 5329 : 1983 - Reaffirmed in 2001)

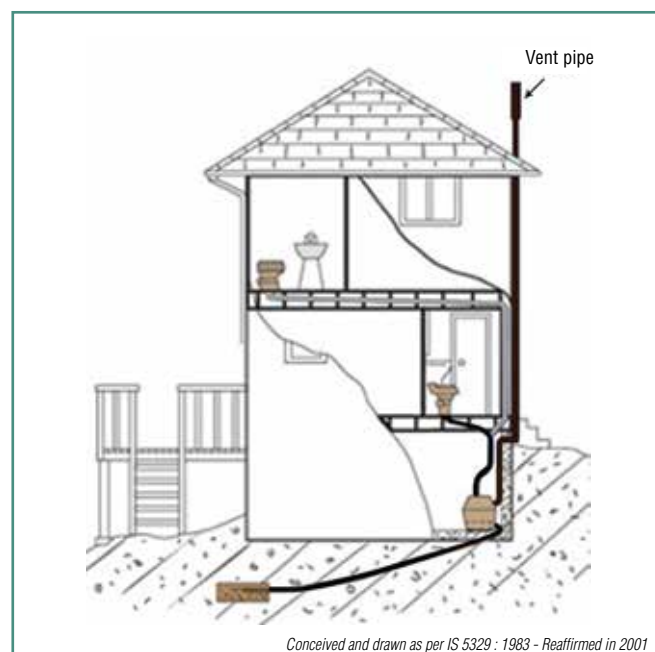
1. Pipe work and appliances should be so arranged as to allow close grouping of connections preferably with a water-closet near the main soil pipe.
2. Connections to main or branch pipes should be so arranged as to prevent cross flow from one appliance to another.

#### Type of pipes

1. When the pipes are concealed, or laid exposed along with the internal face of the walls, they should be preferably metallic.
2. All the pipes laid on the external face of the walls should be made of metal.

#### Size of pipes and bend

1. Bends should be of long radius where practicable. In the case



**Figure 8:** Vent pipe system

of bends in the bottommost pipes, they should necessarily be of long radius and should preferably be made of 135° (1/8) bends.

2. Branches and stacks which receive discharges from WC pans should not be less than 100 mm except where the outlet from a Siphonic WC is 80 mm.

- The gradient of a horizontal branch should not be flatter than 1 in 50 and not steeper than 1 in 10.
- The waste water pipes carrying waste water in any building shall be taken through an external wall of the building by the shortest route and shall discharge below the grating or surface box of the chamber but above the grating of a properly trapped gulley.

### Ventilating pipe systems

- One or more building drain ventilating pipes should always be incorporated in a drainage system and the diameter shall not be less than 75 mm.
- Ventilating pipes should be so installed that water cannot be retained in them. They should be fixed vertically. Horizontal runs should be avoided.
- The upper end of the main ventilating pipe may be continued above roof level as a separate pipe or it may join the main soil pipe (MSP) and/or the main waste pipe (MWP) above the floor level of the highest appliance. The diameter should not be diminished. Its lower end may be carried down to join the drain at a point where air relief may always be maintained.
- In case the adjoining building is taller, the ventilating pipe shall be carried higher than the roof of the adjacent building.
- The upper end of every ventilating pipe should be protected by means of a cowl and mosquito mesh.

### Precautions while using low flow fixture

While using low flow fixtures, care should be taken in the sanitary drainage system to accommodate the lower volume of water in the piping system. One measure can be to reduce the pipe size or increase the slope of the pipe and to increase the velocity of the water flow.

### GROUP EXERCISE

Check the different plumbing systems in the various houses and also visit various stores to understand the material of the sanitary pipes available and installed.

## SECTION 3: Cross connections

### A. Detention and types

#### Cross connection

Refers to a connection between the clean water plumbing system and any other source, which may contribute to the degradation of the quality of clean water. Pesticides, sewage and detergents are some of the most common contaminants during a cross connection.

There are two types of cross connections

- Direct cross connection:** Refers to a physical connection between a potable & non-potable system. Example: Water supply line connected directly to a sewage line (such as a shutoff valve between a potable water-supply line and a non-potable source).
- In-direct cross connection:** Refers to a connection established between water supply system and sewage system due to improper plumbing practices.

### Cross connection between municipal water supply line and drain (sewer) line:

A cross-connection is a point in the distribution system (piping) where non-potable water can be introduced to potable sources. All service lines connected to public water systems are potential cross-connections.

Normally water distribution system is designed so that water flows from the water main through a service line to a property. However, certain conditions can cause water to flow from the property's plumbing back

#### Cross Connection

Direct Cross Connection  
Indirect Cross Connection

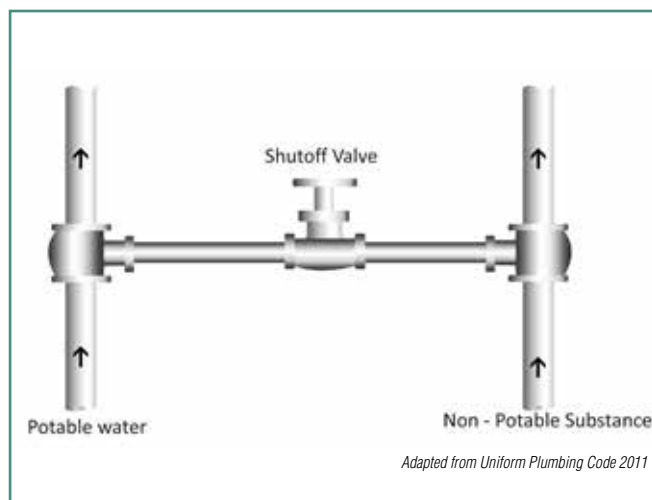
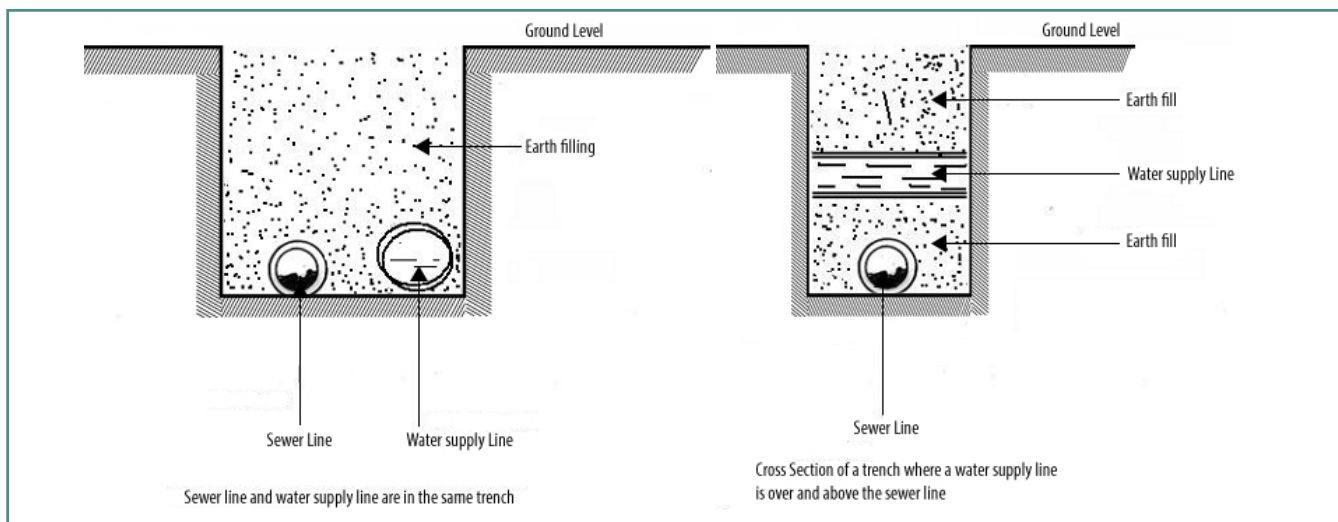


Figure 9: Example of direct cross-connections

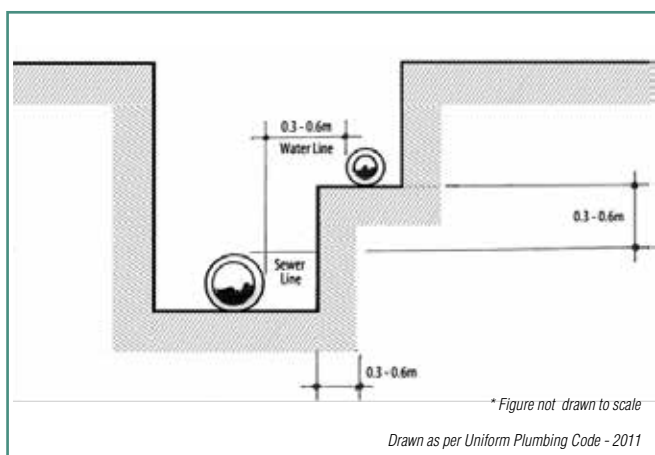
into the distribution system and the local public water supply, creating a potentially hazardous incident. To avoid this, suitable back flow preventing devices may be used.

### How to avoid cross connection between municipal water supply lines and drain (sewer) line:

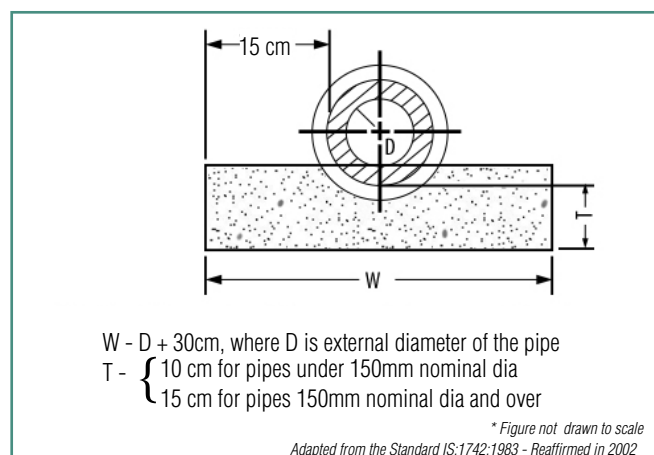
- Horizontal drainage piping shall be run in practical alignment and with slope as per the design.
- The usual practice is that the sewer line laid on one side of the street/road and the water supply line on the other side. In any way the sewer line must be laid in the lower level with reference to the water supply line. The sewer and the water supply line should not be laid in the same trench either in parallel or one over the other as in the following figures
- For variety of reasons either drainage or water pipe may develop leaks over a period of time. The fill material around these pipes will become saturated when leak occurs. **Therefore, it is essential that potable water and waste piping not be allowed to share a common trench.** Saturated soil becomes a bridge for bacterial travel between the pipes. Therefore solid shelf for water line is provided a minimum of 0.3 - 0.6 m above and a minimum of 0.3 - 0.6 m horizontally from the sewer line as shown in **Figure 11**. Please note that the sewer line should be at the bottom.



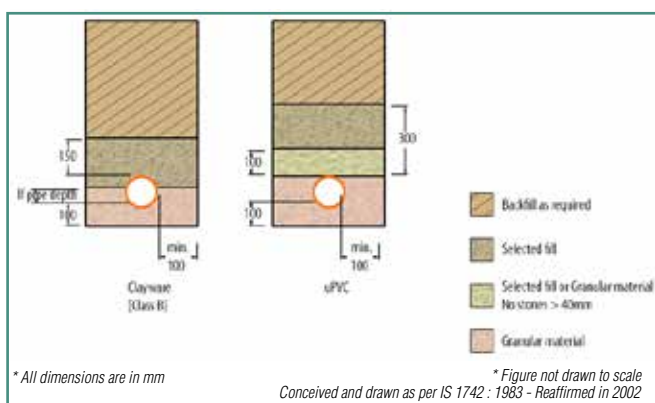
**Figure 10:** Sewer line and water supply line in parallel in the same trench; Sewer line and water supply line one over the other in the same trench - wrong practices



**Figure 11:** Minimum separation between water supply line and drainage line



**Figure 12:** Concrete bedding



**Figure 13:** Granular bedding

#### Tips on bedding:

- Bedding is the material on which a pipe is laid and which provides supports for the pipe. Bedding can be concrete, granular material or prepared trench bottom.
- The trench bottom shall be stabilized by the addition of coarse gravel or rock, in case of very bad soil, the trench bottom shall be filled with cement concrete of appropriate grade.
- The choice of bedding to be selected depends up on the structural load on the pipes.
- The trench must be free from any rock projections. The trench bottom where it is rocky or uneven a layer of sand or alluvial earth equal to 1/3 dia of the pipe or 100 mm whichever is less should be provided under the pipes.

#### Laying clay ware & PVC pipes on granular beds:

Pipes should be laid on a full bed of granular material and NOT propped up on bricks, bits of stone, broken flagstones, etc. The pipe should be settled into the bedding or have the bedding packed beneath it until it is at the correct alignment and level as indicated by the guide line (string), vide the **Figure 13**.

#### B. Avoidance of cross-connections

##### Plumber should do the following to avoid cross connections

- Create Air Gap
- Use Back flow preventers / Devices

#### Cross-connection should be avoided:

- Between public water supply and other water supplies
- Between clean water pipes and grey / black water pipes
- Through submerged inlets
- In plumbing systems to prevent contamination of clean water

**1. Create air gap** – Always raise the faucets above the top of a tub or basin, creating an air gap between the faucet and highest water level in the tub. An air gap is required to prevent the contaminated water from being siphoned back in to the clean water supply under negative supply pressure condition.



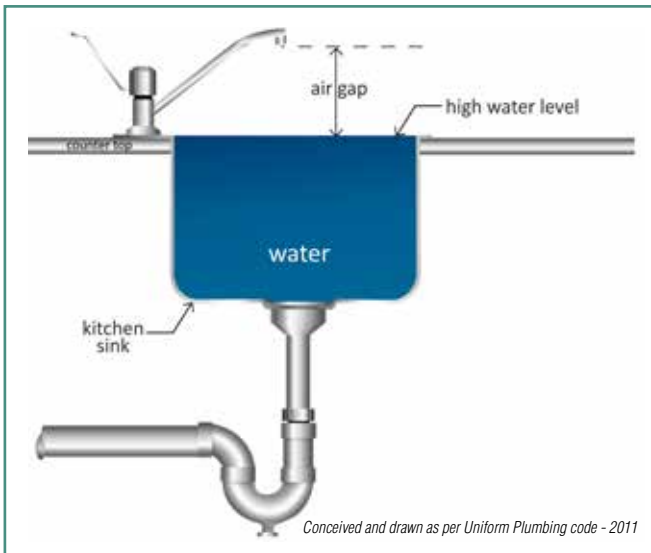


Figure 14: Air gaps in cross connections

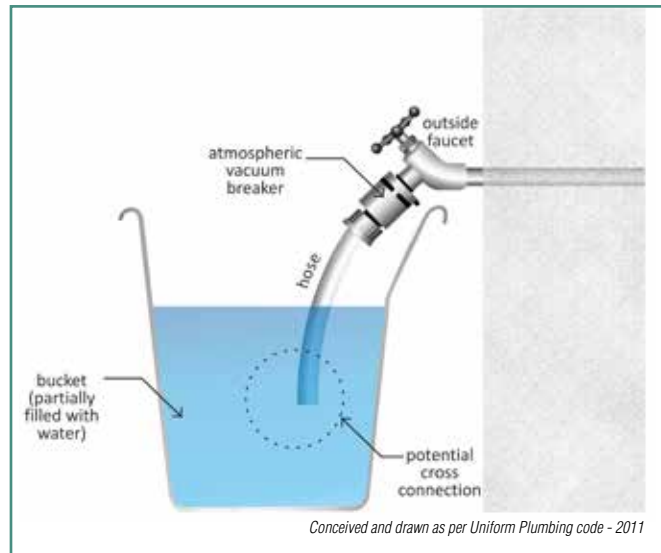


Figure 15: Atmospheric vacuum breaker

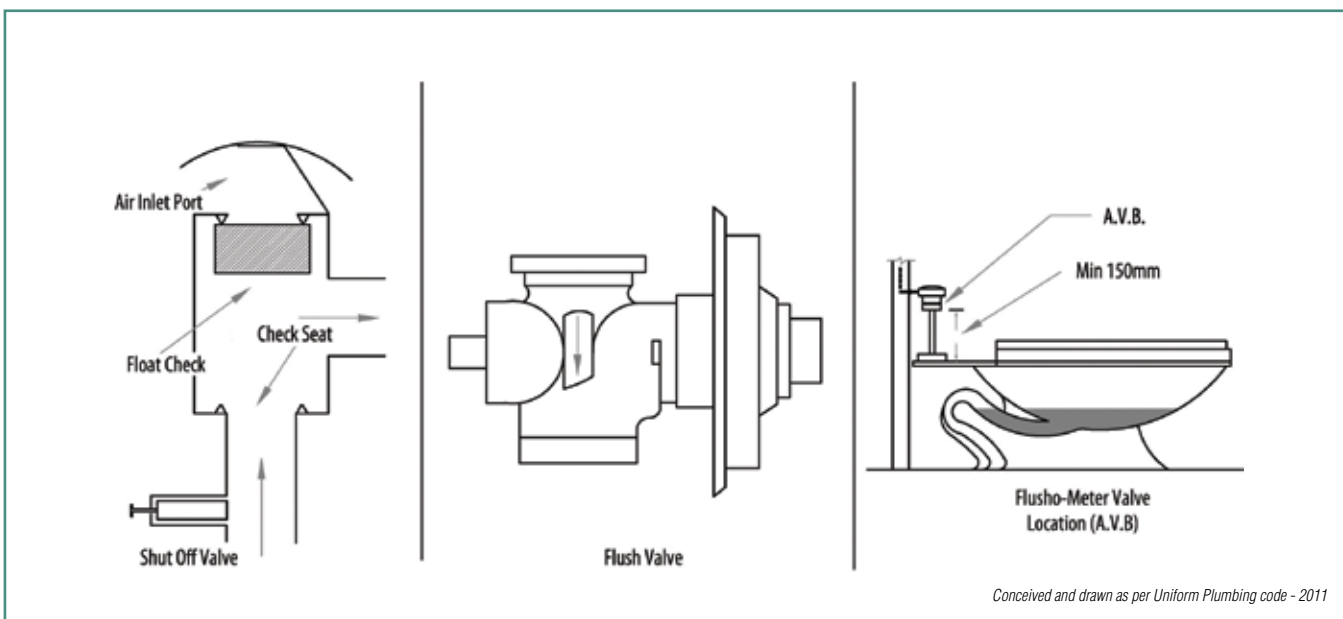


Figure 16: Flush valve with AVB

**2. Back flow preventers / Devices** – Appropriate devices are to be used to avoid reverse flow of waste water. Vacuum breakers are common types of devices to avoid cross connections. There are 2 types of Vacuum breakers – atmospheric and pressure.

**i) How an AVB works:** It contains a float check, check seat, and an air inlet port. As water flows through this device, it causes the float check to rise off a seat, thereby permitting the flow of water. If pressure is lost upstream or if the flow of water is turned off, the float check falls, thereby allowing air to enter the line and preventing backflow.

**ii) Flush valve:** Flushing valves are used in some public lavatories, with push type and self closing valves. However, this system can be adopted where continuous water supply is available. The flush valve body is concealed in the recess in the wall. 32 mm pipe line is required at inlet and at outlet of the valve. The arrow shows the direction of water flow. The valve should be fitted according to the direction of water flow coinciding with the arrow on the valve.

**iii) Pressure vacuum breaker:** A **pressure vacuum breaker (PVB)** is a type of backflow prevention device, used

to keep non-potable (or contaminated) water from entering the water supply. A PVB is similar to an atmospheric vacuum breaker (AVB), except that the PVB contains a spring-loaded poppet. This makes it acceptable for applications that are high hazard or where valves are downstream. Pressure vacuum breakers must be protected from freezing when installed outdoors.

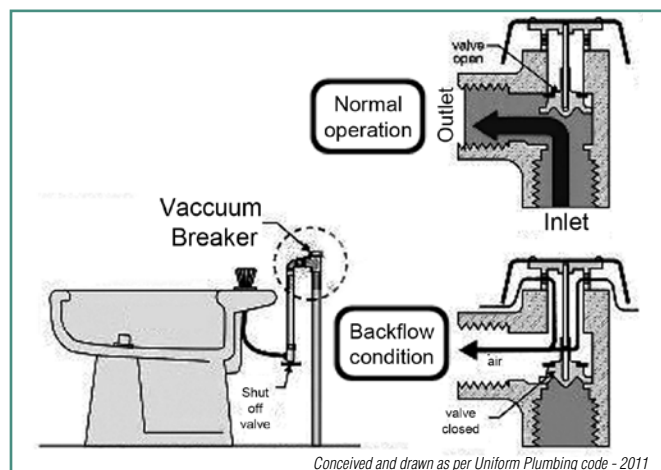


Figure 17: Pressure vacuum breaker

## SECTION 4: Water saving/conservation techniques in plumbing

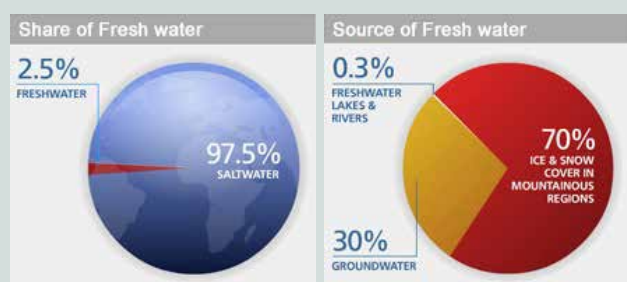
### A. Definition and rationale

**Water conservation:** Refers to strategies, actions and techniques adopted to use water wisely. This is important as:

- Fresh water is a scarce resource
- Water tables are fast depleting
- Rainfall is unpredictable &
- Moral responsibility to conserve water for future generation

#### DID YOU KNOW?

70% of the earth's surface is covered with water, but only 2.5% of that water is fresh water. Of this only 30% is available for drinking as groundwater and is relatively easily obtainable.



#### DID YOU KNOW?

#### Importance of water conservation to house / building septic system

Water conservation is not only important from a sustainable consumption perspective but also relevant to house – septic systems / environment.

- Extends the life of septic system by reducing soil saturation
- Reduces any pollution due to leaks from septic tank with excess water
- Over loaded municipal sewer systems can also cause untreated sewage to flow to lakes and rivers.
- Lesser the amount of water flowing through septic systems, the lower the likelihood of pollution.

#### Tips to conserve water

- Pressure Reducing Valves (PRVs)
- Leakages
- Water meters
- Flow control devices
- Grey Water Use

### B. Tips to conserve water

The different ways to conserve / save water in plumbing are listed below:

1. As per IPC, water pressure in water distribution system should be limited to 80 psi or 55 m of water column in order to remove water hammer, unnecessary use of water, splashing, excessive discharge of pressure relief valves, and to protect appliance valves. Hence reduce the pressure in the distribution line by providing **Pressure Reducing Valves (PRVs)** to regulate and to save water consumption. As recommended the pressure at any fixture unit shall not exceed 2.5 – 3 bar.

No.	Fixtures	Rate of flow in litres /second
1	WC with flushing cistern	0.12
2	Wash Basin	0.15
3	Wash Basin with spray taps	0.04
4	Bath Tub (Private)	0.30
5	Bath Tub (Public)	0.60
6	Shower with nozzle	0.12
7	Sink with 15mm tap	0.20
8	Sink with 20mm tap	0.30
9	Sink with 35mm tap	0.40

**Table 2:** Recommended rate of flow for various fixtures

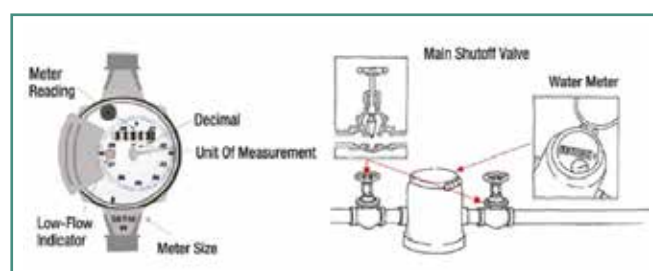
2. The above Table from IS 12183 (Part 1) : 1987 - Reaffirmed in 2004, recommends the rate flow for various fixture units. Hence fixtures which satisfy the minimum flow rate should be used to save water consumption in any building.
3. **Water conservation products** such as Automatic taps, Flushometers, Pint flush urinals, high efficiency toilets and water saving shower heads can also be used. Standard showerheads use about 11 lpm and performance shower heads use about 8 lpm. The older toilets flush with about 13 litres per flush. New high-efficiency dual flush toilets use less than 6 litres per flush.
4. **Leakages** Check for leakage in the pipe line and faucets and seal them. It is estimated that faucet leaks a drop per second will account to 15- 30 litres per day.
5. **Water meters** – It is important to install water meters in key pipe line connection. This will help measure the water usage and can help in measuring output of any efforts to conserve water.



Amount of potential water loss per tap has been calculated based on rate of water leakage from 2 drops per minute to a slow stream breaking into drops. The figure is shown to highlight the potential loss and need for water conservation only

**Figure 18:** Every drop counts

6. **Flow control devices** - Significant water savings results from simply installing new faucet flow-control devices (aerators).
7. **Grey water use** - Grey water can be used by home owners for home gardening, lawn maintenance, landscaping, and other innovative uses with moderate treatment.



\* Figure not drawn to scale

**Figure 19:** Photograph of water meter

### C. Saline water:



**Figure 20:** Photograph of flow control devices

Saline water is a general term for water that contains a significant concentration of dissolved salts. The concentration is usually expressed in parts per million (ppm) of salt. It is normally categorized as TDS in drinking water standards. 500 ppm is acceptable norms for drinking purposes.

Here are the parameters for saline water:

- Fresh water - Less than 1,000 ppm
- Slightly saline water - From 1,000 ppm to 3,000 ppm
- Moderately saline water - From 3,000 ppm to 10,000 ppm
- Highly saline water - From 10,000 ppm to 35,000 ppm
- Ocean water contains about 35,000 ppm of salt.

## SECTION 5: Green plumbing practices

### A. Definition & basics

In India, leading institutions like CII - Green Building Council and TERI's - Green Rating for Integrated Habitat Assessment (GRIHA) National rating system have defined "sustainable requirements that need to be adopted by buildings."

Hence all the new buildings are required to meet certain sustainable requirements defined by the Green Building Council. One of the methods is the development of a certification programme for buildings known as Leadership in Energy & Environmental Design (LEED).

The LEED Green Building Rating System is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. The rating system is divided into six main areas of design. These areas are Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Environmental Quality, and Innovation & Design Process. Each of the areas has specific requirements and prerequisites that must be met in order to qualify for any certification levels. The certification levels and minimum points for each level in the LEED program are as follows:

Certified	26-32 points
Silver Level	33-38 points
Gold Level	39-51 points
Platinum Level	52+ points with a possible 69 points available.

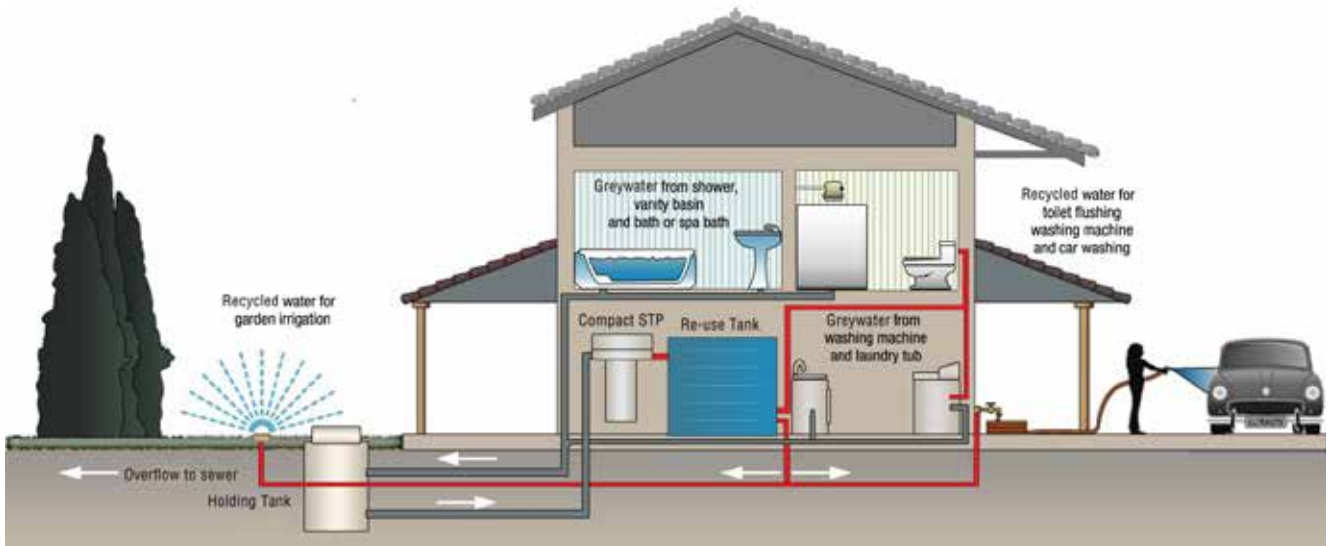
One of the listed areas in the LEED programme is Water Efficiency. The category is sub divided into three sub categories that allow points to be earned by achieving certain criteria established to reduce water consumption.

1. Utilise water efficient Landscaping
  2. Reduction in the use of municipal potable water
  3. Reduction in wastewater through Innovative Wastewater Technologies
- Utilizing **water-efficient landscaping** will reduce the amount of potable water used for irrigation/gardening by 50 percent. This is typically accomplished by using a highly efficient irrigation system, capturing rainwater, or using recycled site water to reduce the consumption of potable water.
  - **Reduction of the use of municipal** potable water, a minimum of 50 percent or treating 100 percent of the wastewater on-site to tertiary standards is required.
  - Under **Innovative Wastewater Technologies** providing ultra-low consumption plumbing fixtures find predominant place in water efficiency. Reductions in water usage beyond what is required can be obtained by using the following in the plumbing system.
    1. Lavatory faucets with flow rates 1.9 lpm,
    2. Showerheads with flow rates of 5.7 lpm,
    3. Water closets that use dual-flush technology
    4. The use of infrared faucets and flush valves
  - **Waterless urinals** have been developed to use a biodegradable, immiscible fluid that is less dense than normal liquid waste and allows the waste to pass through a special trap and then to the drainage system. These products do not connect to the building water supply and do not use water.
  - **Composting water closet systems use little or no water.** An incinerating water closet does not use water and utilizes a combustion chamber in order to incinerate wastes. Use of these units is typically limited to remote locations or locations where water availability is limited. Again, the limitations of code should be examined prior to using these units.
  - **Grey water system** is one of the technologies becoming more prevalent in the design of green plumbing. Grey water is defined as untreated household wastewater which has not come into contact with toilet waste. Grey water includes used water from bathtubs, showers, bathroom wash basins, and water from clothes washing machines and laundry tubs and car washing. It shall not include wastewater from kitchen sinks or dishwashers. In building plumbing work in a two pipe system grey water is dealt with separately. Typically, grey water systems are used to flush water closets, urinals, and gardening and for cooling towers after the required treatment.
  - **Black water:** Grey water does not include the wastewater from toilets, urinals or bidets. The discharges from these fixtures are classified and sometimes referred as black water, because they contain high levels of pathogenic organisms and solids. Such discharges should undergo specialized treatment prior to any secondary use.

- In building plumbing, other than two pipe system, both grey water and black water are collected together and the combination called sewage is disposed. Under green plumbing concept, the sewage is treated in a STP (Sewage Treatment Plant) and the treated water is used for gardening and toilet flushing etc. Here the sewage which consists of black water and grey water is termed as RAW SEWAGE. The sewage treatment design is based on the characteristic of raw sewage.

Under green plumbing concept, the sewage is treated in a compact **STP** (Sewage Treatment Plant) and the treated water is used for gardening and toilet flushing etc.

- Rain water collection:** Under the green plumbing concept, rain water collection and Use for gardening and other purposes considerably reduce the consumption of potable municipal water. The collection systems require the storage of the rainwater, usually in underground storage tanks that can be quite large.
- The amount of storage depends on the requirement for irrigation water, as well as the amount of rainwater anticipated. Moderate water treatment and filtration is necessary to keep the sprinkler heads from fouling and becoming clogged with debris.



**Figure 21:** Grey water recycling

**Common mistakes done by the plumbers:**

	<p><b>Comment:</b></p> <ol style="list-style-type: none"> <li>Plumbing pipes must be routed in such a way that minimum number of bends are involved.</li> <li>The vent pipe should be extended above the roof top and should be provided with a cowl and covered with a mosquito mesh.</li> </ol>
	<p><b>Comment:</b></p> <ol style="list-style-type: none"> <li>The rain water pipe should generally be connected to the street drain/storm water drain and local authority clearance is required for connecting to the sewer system.</li> </ol>



## Case study: Basic concepts of plumbing

**Aim of the Cases** – The aim of the 2 cases listed below is to highlight the various standards established for sanitary plumbing in a building. The following cases will highlight the violations made by plumbers in the layout of sanitary pipes and the corresponding impact that it will have on sewerage disposal / surrounding environment.

**Time allotted:** 20 minutes / Case

**Instruction to Trainer:** – The case is to be discussed at the end of a training session of the chapter. This will serve to recollect key concepts learnt, bring out the level of understanding of trainees and emphasize the real impact behind theoretical concepts.

The trainer will show the photographs to the trainees and explain the various components visible in the photograph to the trainees. Alternatively, one or more of the trainees could be invited to describe the various components visible in the photograph. Then the case is open for discussion for 10 to 15 minutes. The trainer should use a flip chart or board to capture key points of discussion. Finally the trainer is to summarize the discussion and explain the impact of wrong connection depicted in photos.

### Case study 1

Figure of a street



### Case study 2

Figure of a street



### The case is open for discussion and conclude

Trainer's case discussion – key points:

1. Soil pipes shall not be permitted on a wall abutting a street unless the authority is satisfied that it is unavoidable. (IS 5329:1983 - Reaffirmed in 2001)
2. If inevitable, metallic pipes should be used preferably CI. (IS 5329:1983 - Reaffirmed in 2001)
3. In the bottom long radius bend preferably 135° (1/8) bend should be provided to allow soil waste to pass smoothly without blockage. (IS 5329:1983 - Reaffirmed in 2001)
4. A common header pipe would have been thought of.
5. No slope/gradient is provided in the horizontal portion for the smooth flow without any blockage. (IS 5329:1983 - Reaffirmed in 2001)
6. The ventilating pipe should be taken to the roof top, above level of terrace parapet. It should be provided with a cowl and covered with a mosquito mesh. (IS 5329:1983 - Reaffirmed in 2001)

Case Study

## ***Notes***

## CHAPTER 2

# Overview to Public Sanitation Systems and Process

## Chapter Objective:

- Provides a step by step approach to be followed by a plumber in connecting building drainage system to a public sewerage system.
- Highlights the role of a manhole, precautions a plumber has to consider for certain types of traps, right ways to connect various types of pipes and recommendations as prescribed in the national plumbing standards.
- Provides brief description about simplified sewers and small bore systems

**Chapter Duration: 180 minutes\***

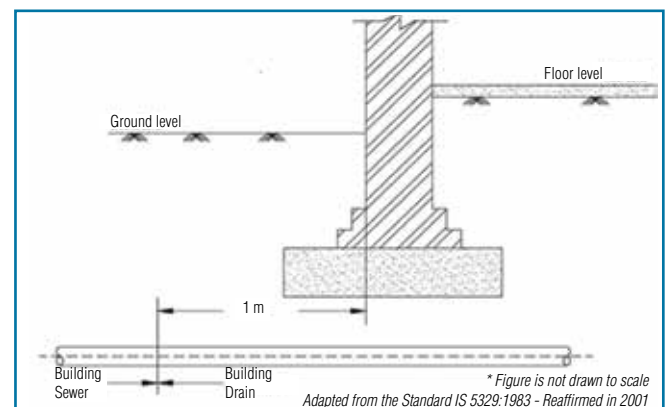
## SECTION 1: Building sewerage & its components

### Basic definitions

**Building drain** – refers to the lowest horizontal pipe of a drainage system which receives the discharge from soil, waste and other drainage pipes inside the walls of the building. It extends for up to 1 meter from building and discharges into the Building sewer.

**Building sewer** – refers to the horizontal pipe of a drainage system which collects drainage from the building drain and discharges the same into the Public sewerage system, private sewer or individual sewage disposal system.

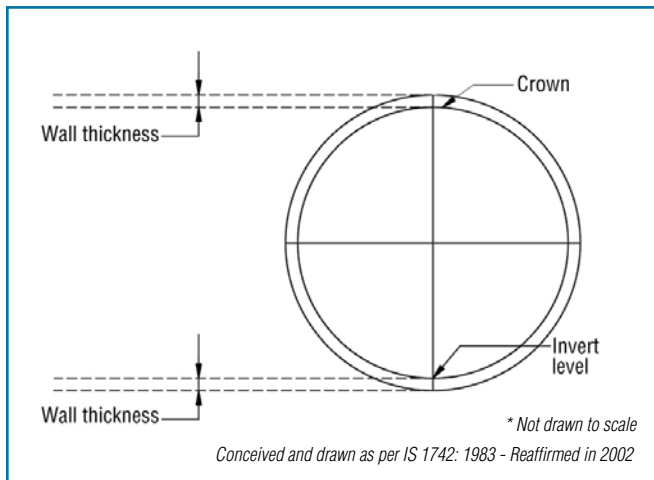
\*duration is only indicative and can be changed based on requirements at different locations



**Figure 22:** Building drain and building sewer

**Invert** – refers to the lowest point of the lower inside surface of a channel, conduit, drain and pipe.

**Crown** – refers to the highest interior level, and can be considered the “ceiling” level.



**Figure 23:** Invert and crown in a pipe

**Public Sewer System (PSS)** – refers to sewerage system operated by municipalities or corporations. It collects sewage / storm water from individual buildings, public areas and transports it for proper disposal. The PSS can be classified into following categories:

#### Public Sewer System

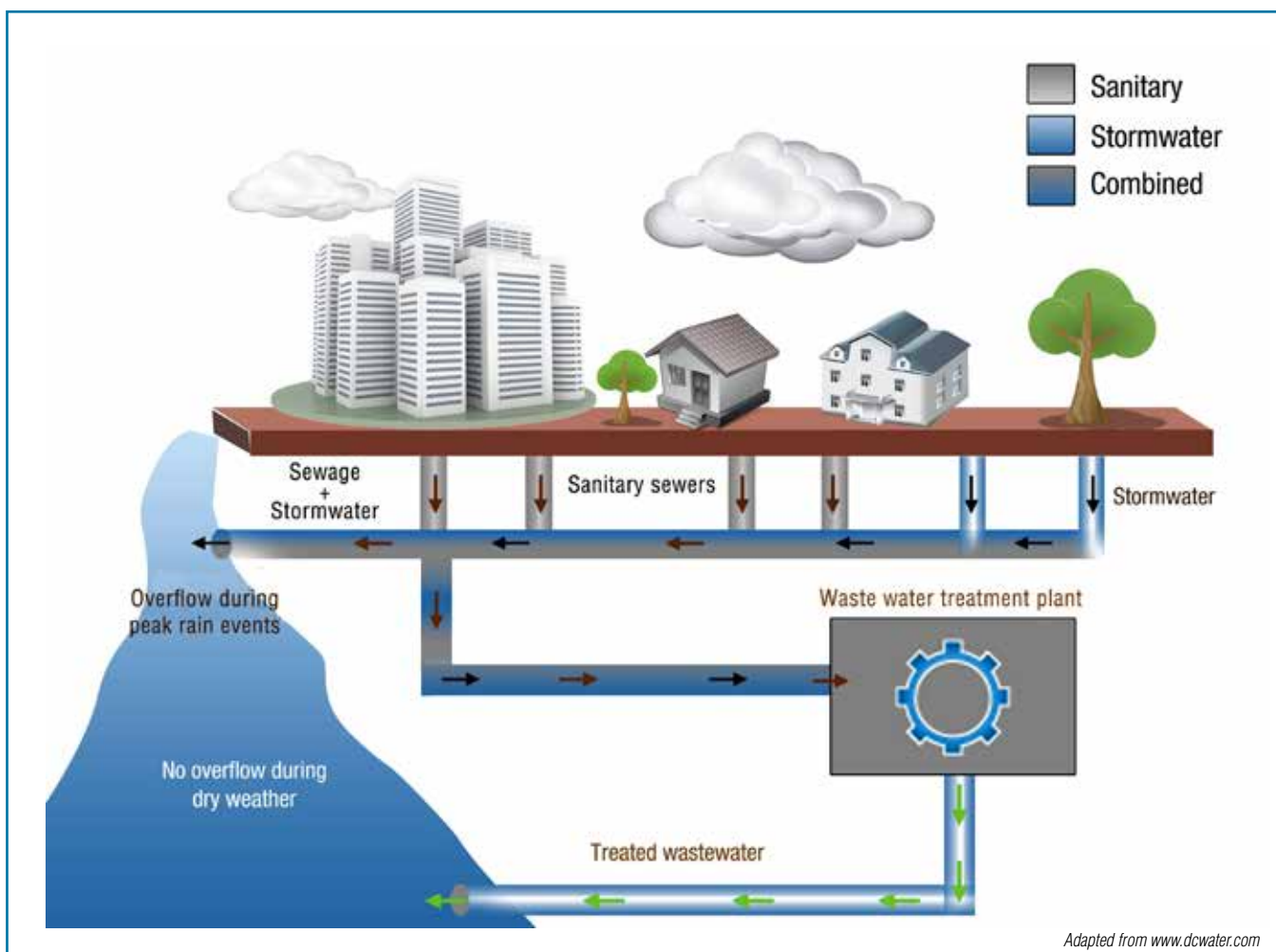
- A. Combined Sewer System
- B. Separate Sewerage Systems
- C. Partially Separate Sewerage Systems

A. **Combined sewer system** – sewage and storm water/surface water runoff are drained through the same pipes in a single pipe system. This system can cause serious water pollution problems when the combined sewer overflows during rainy season or a storm.

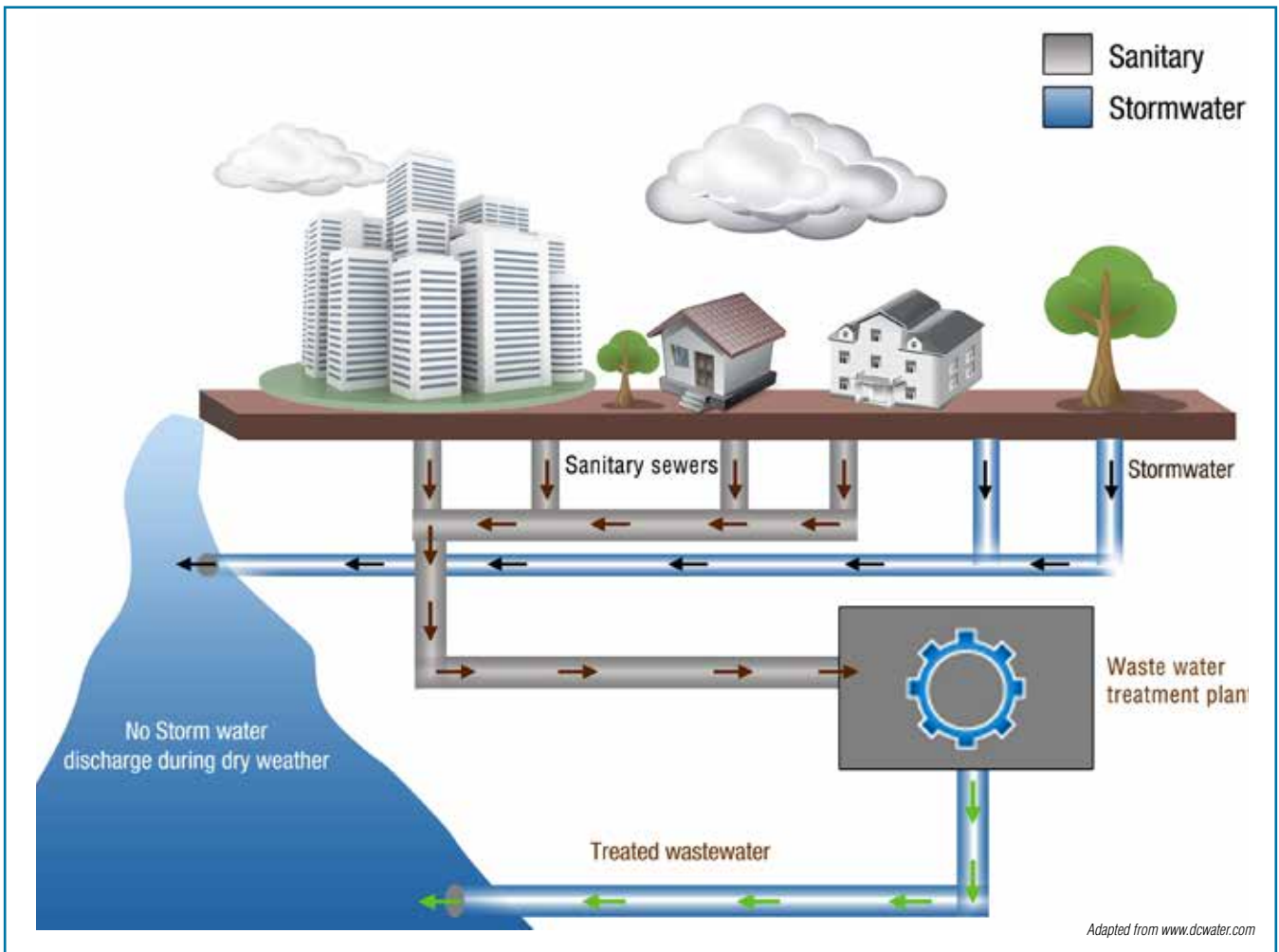
B. **Separate sewer system** – sewage and storm /surface water runoff are drained through two different pipes. Sewage and storm / rain water are handled separately and hence chances of pollution is minimal.

C. **Partially separate sewer system** – part of storm water is mixed with sewage and drained through one pipe and rest of the storm water is collected using another pipe.

**Manhole** – refers to an opening by which a man may enter or leave a drain, a sewer for inspection, cleaning and other maintenance opera-



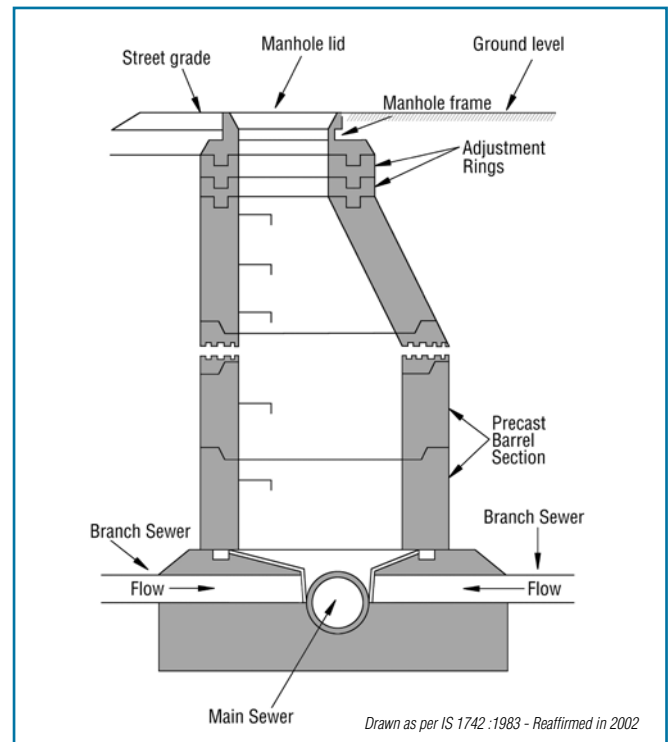
**Figure 24:** Combined sewer system



**Figure 25:** Separate sewer system

tions. Some key details about manhole are listed below:

- **Cover:**
  - Is a cover / lid to close the opening.
  - This is important to prevent accidents and foul gases from polluting the building premise.
  - Circular covers are desirable.
  - Size of the cover should be at least 500 mm for a manhole exceeding 0.9 meters in depth.
- **Structure:**
  - Usually brick walled. Concrete or pre-cast structures are also used.
- **Shape:**
  - Rectangular in shape if manhole is less than 1 meter in depth.
  - Circular manholes are recommended when depth exceeds 1 meter.
- **Standards for compliance:**
  - **IS 1726:1991 - Reaffirmed in 2003 & IS 11972:1987 - Reaffirmed in 2002;** Requirements for manhole covers and frames.



**Figure 26:** Cross section of a manhole

### How to identify manhole / sewer lines / lateral pipes. Use Figures to show.

- Normally the whole sewerage system of any town will be marked on a plan and divided into sections and areas and are placed under a maintenance team.
- The locations of manholes sewers and laterals could be identified from the map.
- In case of very old sewerage systems the location of the manholes could be identified with the use of mechanical devices such as metal detectors etc.
- The location of manholes may be identified by visualizing their covers which are normally metallic.
- The map or the plan will give information on mapping, inventory, and recording of geographical location of all public and private sanitary sewer manholes (by identifying numbers), public and private sewer mains, force mains and air valves, service line cleanouts, and lift stations in the wastewater collection system.
- The Manhole Identifier Map in **Figure 27** illustrates numbering by sewer shed and trunk line, a flexible numbering system, and lower numbers toward each sewer shed outlet,

The mapping of private sewers, may not be available with the maintenance team. The same should be obtained from the property owner.

## SECTION 2: Connecting building drain to public sewer

The Plumber should follow the below mentioned steps in connecting building drain to Public sewer

### Connecting Building Drain to PSS Steps:

- Step 1: Establish Details about the PSS
- Step 2: Connecting – Preliminary Works
- Step 3: Connecting

#### Step 1: Establish Details About The PSS

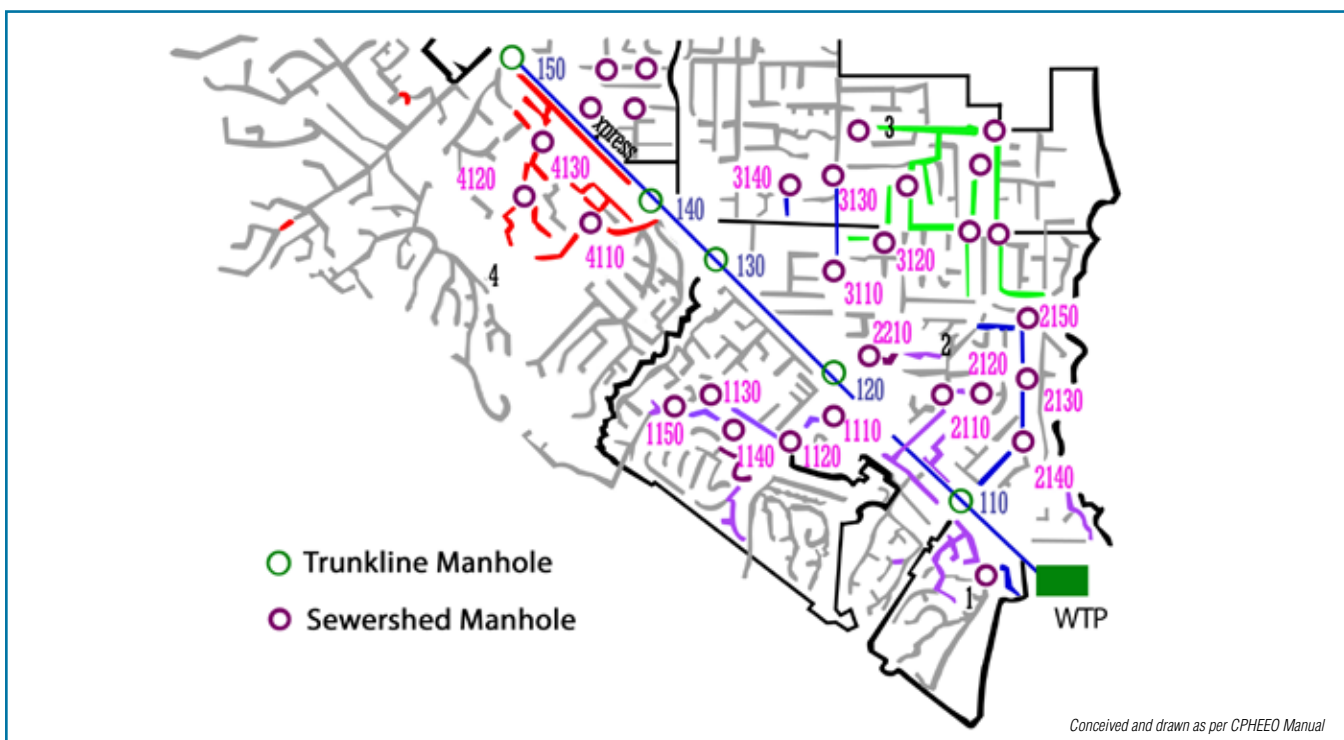
The Plumber should first gather the following details before starting any plumbing work to connect building drainage to Public sewerage system.

- The position of the public sewer in relation to the building
- The invert level of the public sewer.
- Check if the Public Sewer System (PSS) is combined, separate or partially separate system.
- Clarify the lowest level at which connection from building may be made to the PSS.

#### Step 2: Connecting Building Sewerage Pipe To Municipal Manhole – Preliminary Works

**Material to be used** – Material of the Building Sewer shall be either conventional salt glazed stoneware or UPVC rigid straight pipes of 6 kg/cm<sup>2</sup> pressure class in manufacture with solvent cement joints.

**Size of Building sewer connection** – should preferably be 150 mm or more in diameter with a minimum slope of 1:60 laid as far as possible to a straight line and grade. Tips to measure slope are provided at end of this section.



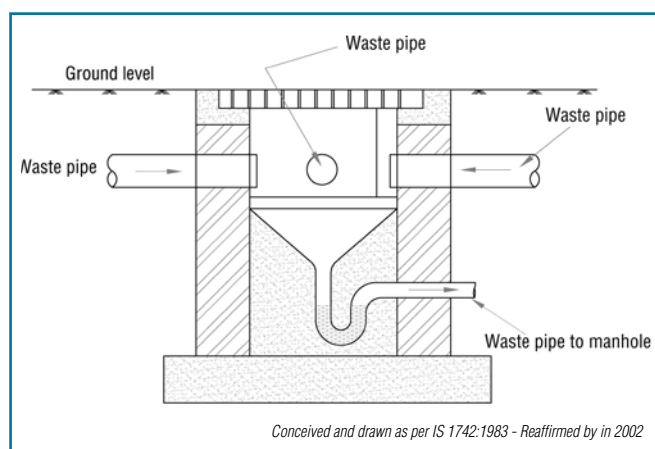
*Conceived and drawn as per CPHEEO Manual*

**Figure 27:** Manhole map / plan

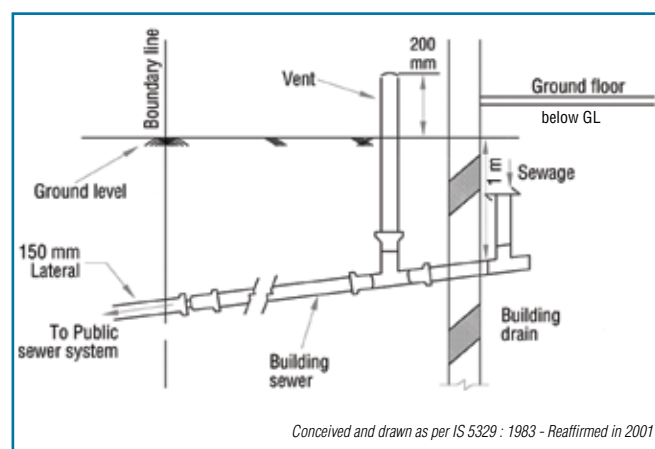




**Figure 28:** Manhole / Manhole covers



**Figure 29:** Waste water / grey water line connected to manhole through gully trap



**Figure 30:** Building drain and building sewer connection

### Procedure for connecting building sewer to manhole:

Before connecting the Building Sewer to the Municipal Manhole, the plumber should verify the following:

1. All drainage pipes from the building are connected to Inspection chamber inside the building premises.
2. Waste / Grey water discharged from the building is connected through a Gully trap to Inspection chamber outside the building. Refer to **Figure 29** for better understanding.
3. Inspection chambers shall be provided at each corner immediately outside the building in case of large buildings.
4. Soil / Black water discharged from building is connected to manhole outside the building directly.
5. It may be noted that a manhole/ inspection chamber is provided **at change of**
  - alignment
  - gradient
6. Where diameters of the incoming and outgoing drain are different, the crown of the two pipes should be fixed at the same level.
7. All inspection chambers in the building are inter-connected and the drain leads to a final inspection chamber within the building premise.
8. Then this final inspection chamber is connected to the Municipal manhole outside the boundary of the building premise in case of large buildings.
9. In case of small buildings, the building drain and building sewer may be connected as illustrated below. The building sewer may be lead to Municipal manhole connection.

#### DID YOU KNOW?

The earlier practice has been to connect house sewers to public sewers using the typical Y branch or T branch depending on the depth of public sewer. It is discontinued and the house service sewer connections are done only in manholes as per recommendations from CPHEEO manual. In case of old sewers, a new manhole shall be inserted for this purpose.

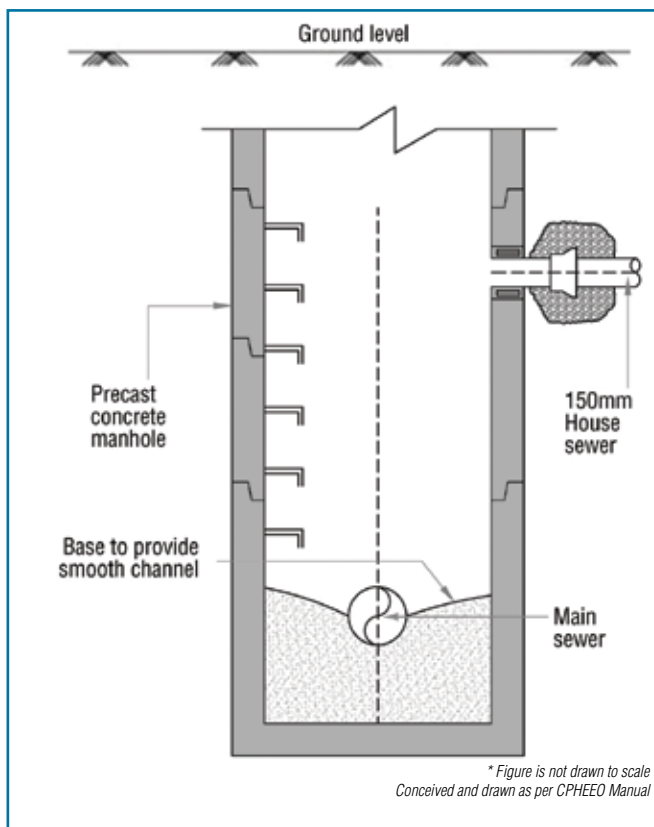


### Step 3: Connecting Municipal Manhole to Public Sewerage System (PSS)

#### Procedure for connecting building sewer to manhole:

The plumber should follow the steps listed below when connecting Manhole at building boundary to PSS.

1. The house sewer should be connected to the public sewer with the approval and as directed by the authority.
2. The building sewer leading to the municipal manhole is called lateral.
3. If the difference in level between the incoming drain and the outgoing sewer is less than 600 mm and there is sufficient room in the manhole, the connecting pipe may be directly brought through the manhole wall and the fall accommodated by constructing a slope in the manhole (Ref: IS 1742:1983 - Reaffirmed in 2002).
4. Intercepting trap is often provided at the junction of a building sewer and a public sewer. This intercepts the foul gas from the municipal sewer, from entering into the building drainage system. This trap is also called as a boundary trap.

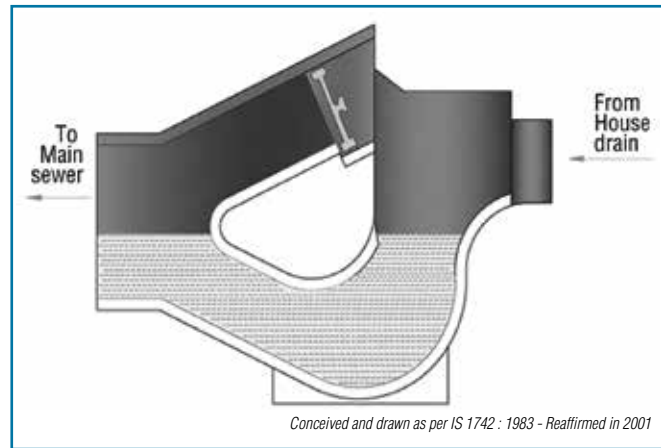


**Figure 31:** Building sewer to manhole connection

The recent practice is to make the house connection directly without providing intercepting traps. Intercepting traps may be useful for multi-storeyed houses.

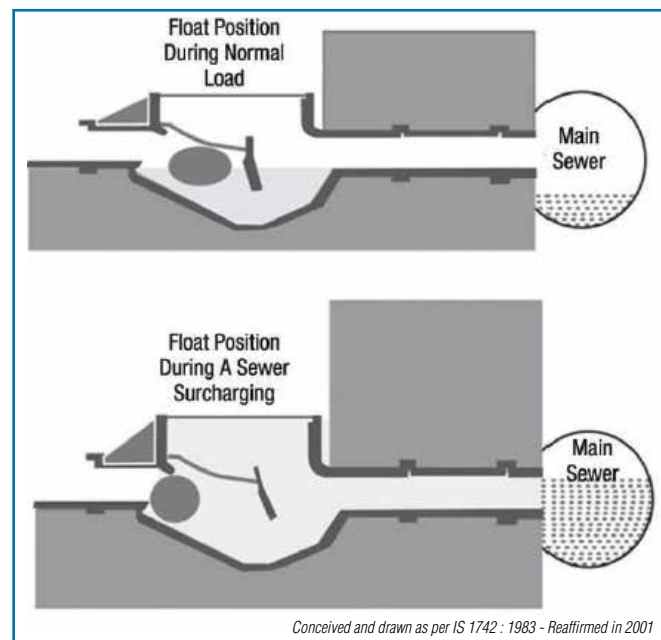
#### Trouble shooting

In case a public sewer becomes surcharged /flooded due to heavy rain



**Figure 32:** Intercepting trap / boundary trap

or storm, gullies and sanitary fittings shall be located above the level of maximum surcharge. Anti-flood valve shall be provided in the manhole nearest to the junction of sewer and sewer drain. Any NRV (Non return valve) can also be used for this purpose.



**Figure 33:** Anti-flood valve

When the elevation of an incoming sewer in a manhole considerably exceeds (greater than 600 mm) that of the outgoing sewer; a vertical waterway outside the manhole is provided to divert the waste water from the upper to the lower level so that it does not fall freely into the manhole except at peak rate of flow. This arrangement is called drop down manhole.

#### Tips to measure the gradient or slope while laying pipes.

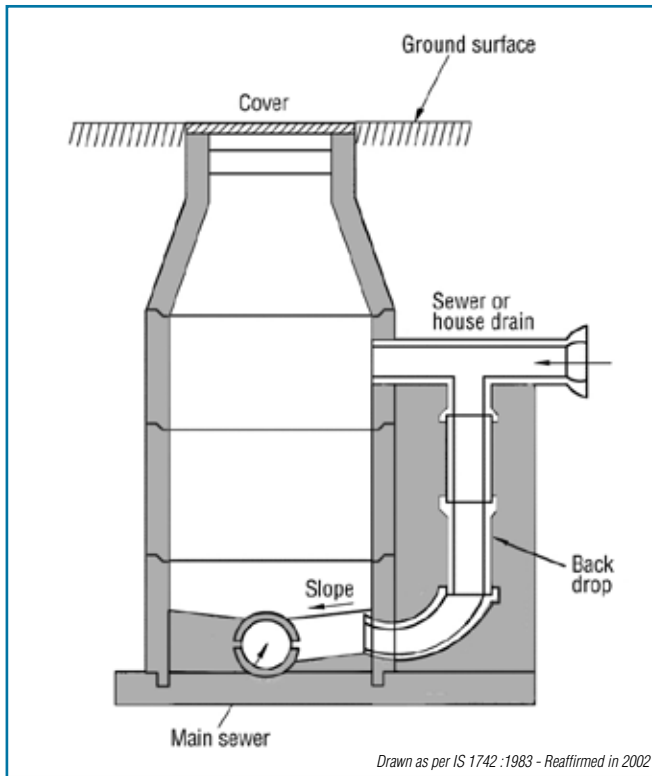
*Pipe slope / gradient:*

Slope or gradient may be defined as fall divided by the distance.

**Gradient = Fall / distance**

*Sample Calculation of fall:*

If your drainage pipe length (L) is 15 metre, what is fall (F) required to attain gradient of 1:60?



**Figure 34:** Drop down manhole

Answer:

Slope of 1:60 means the slope will fall 1 meter for 60 meter length of pipe.

Our Pipe length (L) = 15 meters

So Fall = Gradient \* distance

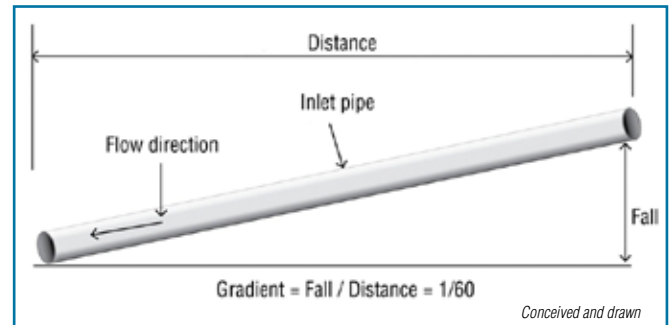
Fall =  $1/60 * 15 = 0.25$  meters

Fall should be 0.25 m or 25 cm.

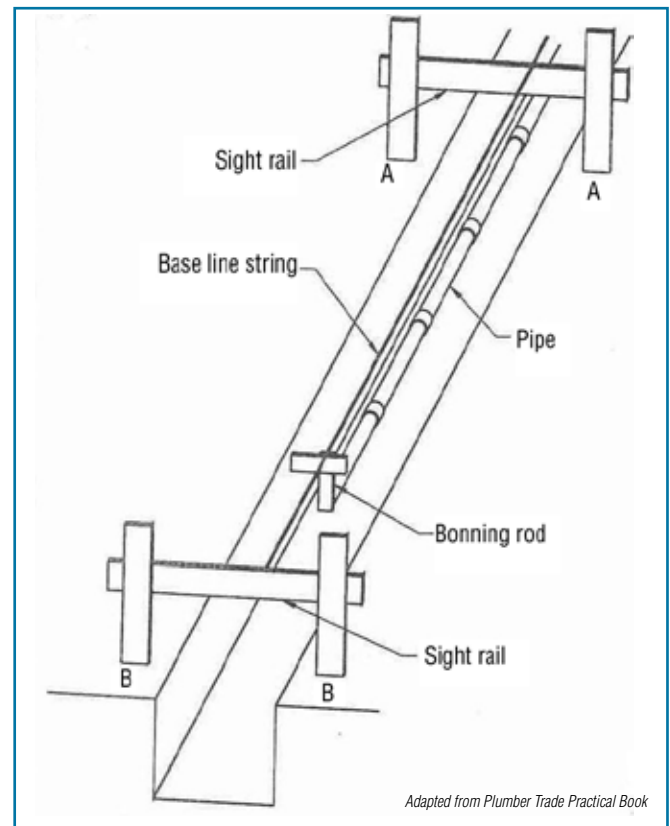
**Procedure to measure gradient for laying of sewerage pipe:**

1. Mark the width of the trench on ground with chalk powder and start excavating to the required depth.
2. Drive two pegs on the side of the trench at the starting point at a distance of 600 mm from the trench mark.
3. Mark the level on both pegs using water level. Fix a sight rail at the mark.
4. Calculate required slope up to the end of the trench as illustrated in **Figure 36**.
5. Fix two more pegs at the end as done earlier.

6. Mark the level considering the slope required.
7. Fix a sight rail at mark.
8. Tie a string from sight rail at the starting point to the end tightly.
9. Check the bottom level of the trench using a boning rod. (Level of trench to be exactly equal from string)



**Figure 35:** Fall and gradient in drainage pipe



**Figure 36:** Measuring gradient / slope

Sewerage pipes are to be laid as per the gradient recommended to have normal flow bearing in mind the self-cleaning velocity to avoid settlement of sewage in the pipe line. In places where required gradient is not conducive, care should be taken to lay the pipes in such a slope that the flow of sewage inside the pipe is smooth and non clogging.

### SECTION 3: Simplified sewers and small bore systems

**SIMPLIFIED SEWERS: Simplified sewers or Condominial sewers** are low-cost sewers which are mainly used in high-density, low-income settlements especially where laying of sewer lines are problematic.

They consist of a network of small diameter pipes laid flat on the ground away from traffic or vehicle movements. Since it is mainly used in low income settlements, the technology is cheaper than conventional gravity pressured sewerage system. As simplified sewers are used in residential areas, they can be laid at relatively shallow depths due to the absence of heavy traffic.

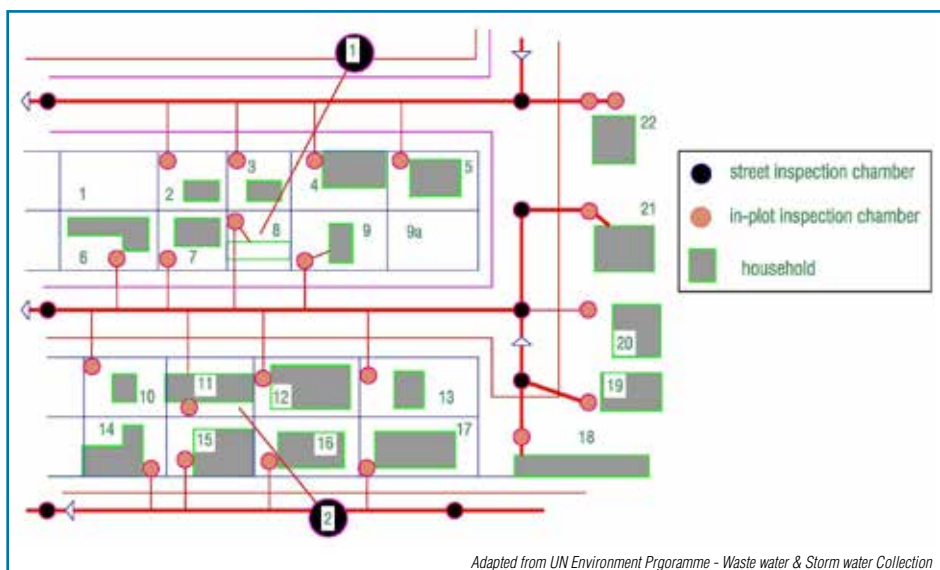
The design of a simplified sewer is basic, having a layout with inspection chambers instead of manholes. This reduces construction costs, facilitates cleaning, and makes it easier and cheaper to connect households to the system.

**Discharge/Outlet:** Typically several houses are connected to the same sewer

1. Connected to a conventional street sewer.
2. The waste water can be discharged into a septic tank set up for the community and then by a small bore sewer to any other form of secondary treatment.
3. The discharge can be sent to the Sewage Treatment Plant (STP) directly for further treatment.

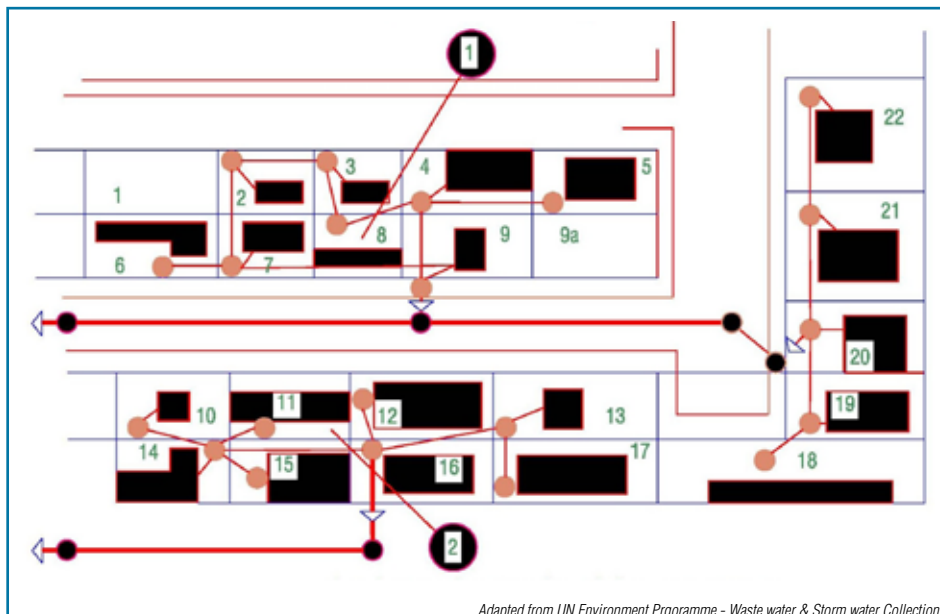
**Advantages:**

- This systems reduces water requirement compared to the conventional sewerage system since the simplified sewer systems are designed for frequent flushing.
- Lengths of pipe are reduced since short house service connections are required.
- Reduced excavation costs since shallow depths are adopted.
- Reduced material cost since small diameter pipes are used.
- Reduced maintenance requirements.
- Reduced treatment requirement.
- Cost of construction of simplified sewerage is 30 to 50 % less than conventional sewerage



Adapted from UN Environment Prgoramme - Waste water & Storm water Collection

**Figure 37 A:** Conventional gravity sewers layout



Adapted from UN Environment Prgoramme - Waste water & Storm water Collection

**Figure 37 B:** Condominium sewer - simplified sewer layout

Connections in Simplified sewer grid can be of two types

- Fishbone grid system
- Right angle / rectangular grid system

**Fish bone grid system/ Herring bone system:**

The layout has the similarity of Herring Fish. It consists of parallel laterals that enter the main from either side at angle. The main line or sub main lies in the narrow depression, particularly suitable where laterals are long & required area to be thoroughly drained.

Laterals enter the main only from one direction hence the cost of this system is comparatively less. This system is used on flat land/regularly shaped field on uniform soil.

Placing the main on each side of depression serves a dual purpose. It intercepts the seepage & provides outlet for the laterals. (Ref: AgriInfo.in)

**Rectangular Grid system:**

Simplified sewers of rectangular grid are best suitable for dense informal settlements where laying sewer lines are often problematic due to the unplanned, irregular layout of buildings and streets.

**DID YOU KNOW?**

Settled sewerage originated to convey the overflow from septic tanks where the soil cannot cope or absorb the overflow. This usually occurs when the groundwater table is high, or where the soil permeability is low, or where there are rock outcrops. This was developed to overcome problems with failing septic tanks; it has been used quite widely to upgrade septic tank systems.

**Small bore system – settled sewerage system**

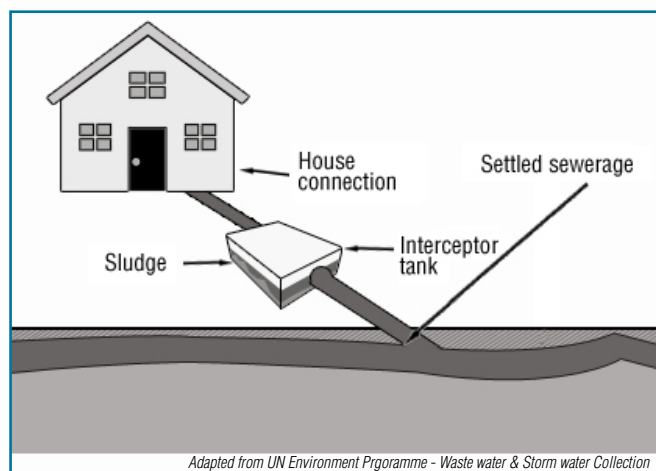
Settled sewerage system or solid free sewers refer to the sewerage system required for conveying the wastewater that is pre-settled and where solids have been removed. Ideally solids would have settled for example in a septic tank.

**Settled sewerage system**

This method is known as Septic Tank Effluent Disposal Scheme (STEDS). The idea is that only liquid water flows through the system. Settled sewerage requires that only connections from septic tank are made to the settled sewer. Septic tanks are regularly emptied of solids to prevent solids from passing through.

**Sewered interceptor tank**

This system is known as Sewered Interceptor Tank Systems (SITS). Where there is no existing septic tank, an interceptor box or tank can be used and functions like a septic tank. As a result, since there is no requirement for the self-cleansing velocity to remove solids, small bore sewers can be used. Since the sewers are not required to carry solids, large quantities of water are not needed for solids transport. The cost of settled sewerage is between a third and a half of conventional sewerage. The waste water from a group of houses can be connected to one



**Figure 38:** Interceptor tank in settled sewerage system

interceptor tank. Just like in a septic tank, the accumulation of sludge has to be removed regularly from an interceptor tank. The sewers are small bore plastic pipes of minimum diameter of 100 mm. The effluent from interceptor tanks transported through small-bore sewerage can be discharged into conventional sewerage or treated locally in a decentralized wastewater treatment plant.

**Vacuum sewers:**

Low-cost sewers conveying wastewater to distributed treatment systems and various alternative and advanced onsite systems are known collectively as “decentralized wastewater technologies”. The collection systems typically are called “alternative collection systems”. One such system is vacuum sewers.

The vacuum sewer collects sewage from multiple sources and conveys it to a central location where it can be treated. As the name suggests, a vacuum is maintained in the collection system and when a house sewer is opened to atmospheric pressure, sewage and air are pulled in to the sewer, whereby the air forms a “plug” in the line, and air pressure pushes the sewage to the vacuum station. This differential pressure comes from a central vacuum station.

These sewers can take advantage of available slope in the terrain, but are most economical in flat terrain. Vacuum sewers have the limited capacity to pull water uphill may be to 9 m. Vacuum sewers are designed to be watertight since any air leakage in to the system reduces the available vacuum.

Vacuum sewers do not require a septic tank at each waste water source. All of the domestic waste water and waste constituents are collected and transported by this collection method. Sewage from one or more homes flows by gravity in to a small valve pit. A service line connects the valve pit to the main vacuum line.

Vacuum stations will consist of two or more vacuum pumps and a large vacuum tank. The pumps run 3 – 5 minutes cycles or long enough to create adequate vacuum in the system. The tank at the vacuum station holds the vacuum on the collection network and prevents the vacuum pump from having to operate continuously. As valve pits are activated, there is loss in the vacuum (negative pressure) in the system. When the negative pressure reaches a threshold level, the vacuum pumps reengage to pull more vacuum. When sewage reaches the vacuum station, it flows in to a collection tank. Sewage pumps are then used to convey the collected sewage through a force main to the treatment component.

A disadvantage is the need to ensure unfailing power supply to the pumps and hence this system is perhaps limited high profile condominiums

Terminology	Description	Benefits	Where it could be applied	Limitations
<b>Simplified sewers</b>	Sewers are laid at shallow depths and manholes are replaced with access chambers for cleaning.	Reduced cost and ease of maintenance.	In residential areas where traffic loads are low	Protection, in the form of concrete surround or cover slab, required at road crossings
<b>Small-bore sewerage (also known as solids-free sewerage or SITS—sewered interceptor tank systems)</b>	Interceptor tanks on household connections and small pipes of 100 mm diameter.	Removal of settleable solids in interceptor tanks reduces sedimentation in sewers and allows them to be laid to much shallower Gradients.	Where ground slope is low or the water table is high.	Regular removal of solids from interceptor tanks required. Vulnerable to illegal connections by households.
<b>Vacuum Sewers</b>	Vacuum sewer system uses the differential pressure between atmospheric pressure and a partial vacuum maintained in the piping network and vacuum station collection vessel.	Reduced cost. Vacuum sewers offer exceptional environmental, operational and financial benefits.	Construction of conventional gravity system would be costly. Housing density is low. Terrain slopes are insufficient or too steep. Groundwater tables are high.	Only the few pumps in the vacuum station need electrical power, service and maintenance.

Technology options for Urban sanitation - MoUD

**Table 3:** Alternative sewerage options for residential areas**FIELD STUDY EXERCISE**

**Place to Visits:** Visit a building whose sewer is connected to public sewerage system:

**Exercise**

- Divide Trainees into groups of 4 people.
- Ask them to prepare a checklist of key items to be inspected in the field visit
- Make each group inspect the draining system using their checklist and report findings

**Points to check:**

1. Under which drainage system, the building sanitary pipe work is done.
2. Is there a boundary trap?
3. Is there any anti flood valve?
4. Is the wastewater line connected to the sewer through gully trap?
5. In the bottom of the soil line, is there a bend with long radius?

**Quick Test: To recap the key points in the chapter.**

Check and tick if the following statements are True or False

	True	False
The discharge from water closet and urinal is called grey water		
A fixture acts as a bridge		
The soil appliances which collect and discharge excretory matter discharge through traps into a soil pipe and then to the building drain through a gully trap		
The two pipe system contains one soil pipe, one waste pipe and one ventilating pipe		
In the two pipe system, the separation between black water and grey water is not possible		
Building sewer is the extension of building drain		
In plumbing, the highest point or the highest inside surface of a channel, conduit, drain, pipe, or sewer pipe is the invert level		
In the case of bends in the bottom most pipes, they should necessarily be of long radius and should preferably be made of 90° bends		
All the pipes those laid on the external face of the walls should be made of metal		
Ventilating pipes may be fixed horizontally		



### Case study: Overview to public sanitation systems and process

**Aim of the Cases** – The aim of the first 2 cases listed below is to highlight the various standards established for connecting a building drainage to PSS. Cases will highlight the violations made by plumbers in connecting building drainage to PSS and the corresponding impact that will have on sewerage disposal / surrounding environment.

**Time allotted:** 20 minutes / Case

**Instruction to Trainer:** – The case is to be discussed at end of a training session of a chapter. This will serve to recollect key concepts learnt, bring out the level of understanding of trainees and emphasize the real impact behind theoretical concepts.

The trainer will show the photographs to the trainees and explain the various components visible in the photograph to the trainees. Alternatively, one or more of the trainees could be invited to describe the various components visible in the photograph. Then the case is open for discussion for 10 to 15 minutes. The trainer should use a flip chart or board to capture key points of discussion. Finally the trainer is to summarize the discussion and explain the impact wrong connection depicted in photographs would have.

This will create a lasting impression / retention among the trainees.

#### Case study 1

##### Case Description – key points:

1. A rain water pipe is running along the column (Pipe Damaged)
2. MH outside the building.
3. A septic tank
4. The building drain is connected to the septic tank. The rain water is also connected to the drain.
5. Septic tank outlet is connected to the Municipal MH on the road.
6. It is ascertained that the septic tank has not been desludged for quite some time.



Outlet

Septic Tank  
Manhole

Manhole

Rain water  
pipe

Figure of a multi-storey building

### The case is open for discussion among the trainees

Trainer's case discussion – key points:

1. Rain water pipes should not be connected to the building drain and in turn to the street sewer without approval of the authority as this action will over load the street sewer and the chances of street sewers getting flooded very high. The rain water pipe should be normally connected to the storm water drain.
2. The septic tank should be provided with a ventilating pipe.
3. The septic tank acts like an interceptor tank. This has to be cleaned periodically.



Extension of soil  
pipe for ventilation

Soil pipe

Soil pipe discharge  
to the septic tank

Waste water  
pipe

Figure of a residential building with one floor

#### Case study 2

##### Case Description – key points:

1. The area is not sewered.
2. Soil pipe discharge into a septic tank.
3. Wastewater line discharges into the street drain.



Waste water pipe  
to street drain

## Case Study

4. Vent pipe diameter should be of the same diameter as soil pipe. In the Figure the vent pipe diameter is smaller than soil pipe.
5. The vent pipe is not extended up to the roof top.
6. Septic tank outlet is not connected to the PSS or any individual disposal system.
7. No vent pipe for the septic tank.
8. It is ascertained that the septic tank is cleaned once in a year.

#### Trainer's case discussion – key points:

1. The septic tank should be provided with a ventilating pipe and effluent disposed.
2. The vent pipe should be of the same diameter of the soil pipe (IS 5329:1983 - Reaffirmed in 2001)

#### Case study 3

**Aim of the Case** – The aim of the case study listed below is to highlight the concepts of simplified sewer and small bore system. The schematic diagram will be used to highlight key concepts to the plumber.

*Figure of a small diameter sewerage system*



#### For interaction with trainees

Questions to be answered:

1. What does the Figure represent?
2. Area suitable for adoption?
3. What are the special components involved?
4. Limitation or precaution required

Trainer's case discussion – key points

1. This is a Small bore sewer system also known as Settled sewerage system or Septic Tank Effluent Disposal Scheme (STEDS) or Sewered Interceptor Tank Systems (SITS)
2. Area suitable for adoption:
  - i) To convey the effluent from septic tanks where the soil cannot cope or absorb the effluent. This usually occurs when the groundwater table is high, or where the soil permeability is low, or where there are rock outcrops.
  - ii) Where new sewerage network is introduced the septic could be linked with the network with small bore pipes without much expense.
  - iii) In places where per capita water supply is limited up to 25 lpcd. Since the sewers are not required to carry solids, large quantities of water are not needed for solids transport. Thus, unlike conventional sewers, small bore sewers can be used without fear of blockage. Lower gradients can be used.
3. Special Components involved
  - i) Inspection chambers
  - ii) Sewage treatment plant
4. Limitations – The septic tank or the interceptor tank as the case may be cleaned or desludged periodically.

## Case Study

## ***Notes***



## CHAPTER 3

# Sewerage Connections – When New Public Sewerage Network is Commissioned

## Chapter Objective:

- The chapter highlights the additional details that plumbers should know in connecting building sewage to the new public sewerage system.
- It briefs about the delinking of the existing septic tank and connecting the building drainage to the PSS. Secondly, the septic tank being connected to the PSS through small bore system.

**Chapter Duration: 80 minutes\***

## SECTION 1: New PSS network

### Municipal byelaws

The Municipal byelaws provide laws for the owner of any property to dispose off his wastewater in a proper manner without causing any nuisance to others. Wherever Municipal sewers exist with some specified distance, it is obligatory that the wastewater of the property is discharged into it. The byelaws provide for action against defaulting owners.

However, in the case of areas not originally served with sewerage facilities, the owners may have to be persuaded to avail of the facilities provided to dispose off their wastewaters and in some cases it may even become necessary for the local body to show some incentive like loan/subsidy for getting the works necessary to dispose the waste water into such municipal sewers.

Advantage of PSS:

1. The property is free from pollution.
2. The owner need not bother about the disposal of sludge and safe disposal of effluent from the septic tank by the way of secondary treatment.

3. In the absence of PSS, the sight of Septic tank and the ventilation pipes is an eyesore in the premises.
4. In the absence of PSS, the septic tanks and the effluent disposal occupy a sizable quantity of land area.
5. If the effluent is not disposed safely, the incumbents may be subjected to health problems.

### Disposals of building drainage

It is the usual practice where public sewerage system is available; the house drain should be connected to the public sewer with the approval and as directed by the authority.

Where discharge into a public sewer is not possible, the drainage of the building normally done through one of the following individual disposal systems:

- a) Leaching cess pool
- b) Collecting in well, cleared periodically and wastes taken to a central treatment and disposal site; and
- c) Septic tank and the effluent is discharged in to soil absorption system, Biological filters and up flow anaerobic filters.

\*duration is only indicative and can be changed based on requirements at different locations

Now when a new sewerage network is commissioned, the building owner is left with the following options:

Alter Building drainage system and connect to PSS

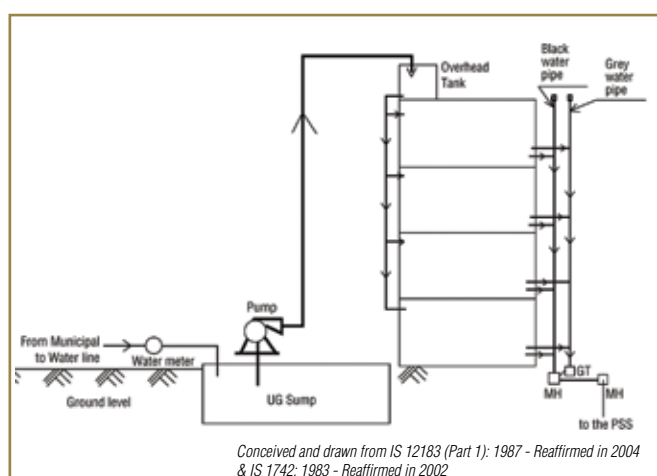
- bypassing the septic tank
- via the septic tank

## SECTION 2: Alteration of building drain to PSS (bypassing the septic tank) and alteration via septic tank to PSS

### Drain Connected to Septic Tank

Option 1 – Delinking

Option 2 – Septic Tank as interceptor tank



**Figure 39:** Water supply and sewerage system of a building – the drain connected to PSS

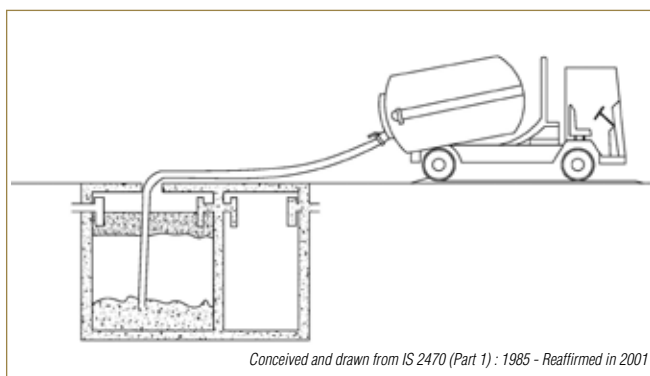
### A. Option 1

Delink the drainage connection to the existing septic tank inside the premises, get a new service connection from the authority and connect the house drain to **PSS with the approval of the authority**. The connecting building drain to public sewer system is already explained in Chapter 2: Section 2. The existing septic tank should be desludged and the structure should be removed immediately.

- Steps involved in desludging the septic tank:
  1. Manual handling of sludge is prohibited on public health point of view.
  2. Care should be taken that the sludge does not spread on the ground.
  3. The plumber should bear in mind the design period of the septic tank for sludge withdrawal.
  4. Before the end of design period, it should be ensured that the tank is not full and attain the condition of overflow. Then start desludging. If the sludge layer is within 300 mm of the bottom of either the inlet or outlet, or if the bottom of the scum layer is within 75 mm of the bottom of the outlet, the tank should be desludged.

5. Sludge should be withdrawn using a dip pipe of not less than 150 mm under a hydrostatic pressure of 450 mm.
6. The sludge pipe shall deliver the sludge to a sump and provided with a delivery valve to draw the sludge as required.
7. Portable pumps may be used avoiding sludge pipe and pump.
8. The sludge should be conveyed to a suitable vehicle for removal from the site.
9. The latest trend is to engage a Vacuum tanker for desludging a septic tank.
10. Supposing, the tank is full and tank start delivering the waste water entering the tank and the septic tank is connected to the PSS through SBS, then the small bore pipe designed to carry liquid only may not be able to convey the solid waste causing blockage. This should be avoided by pre-planning the desludging activity.

### B. Option 2

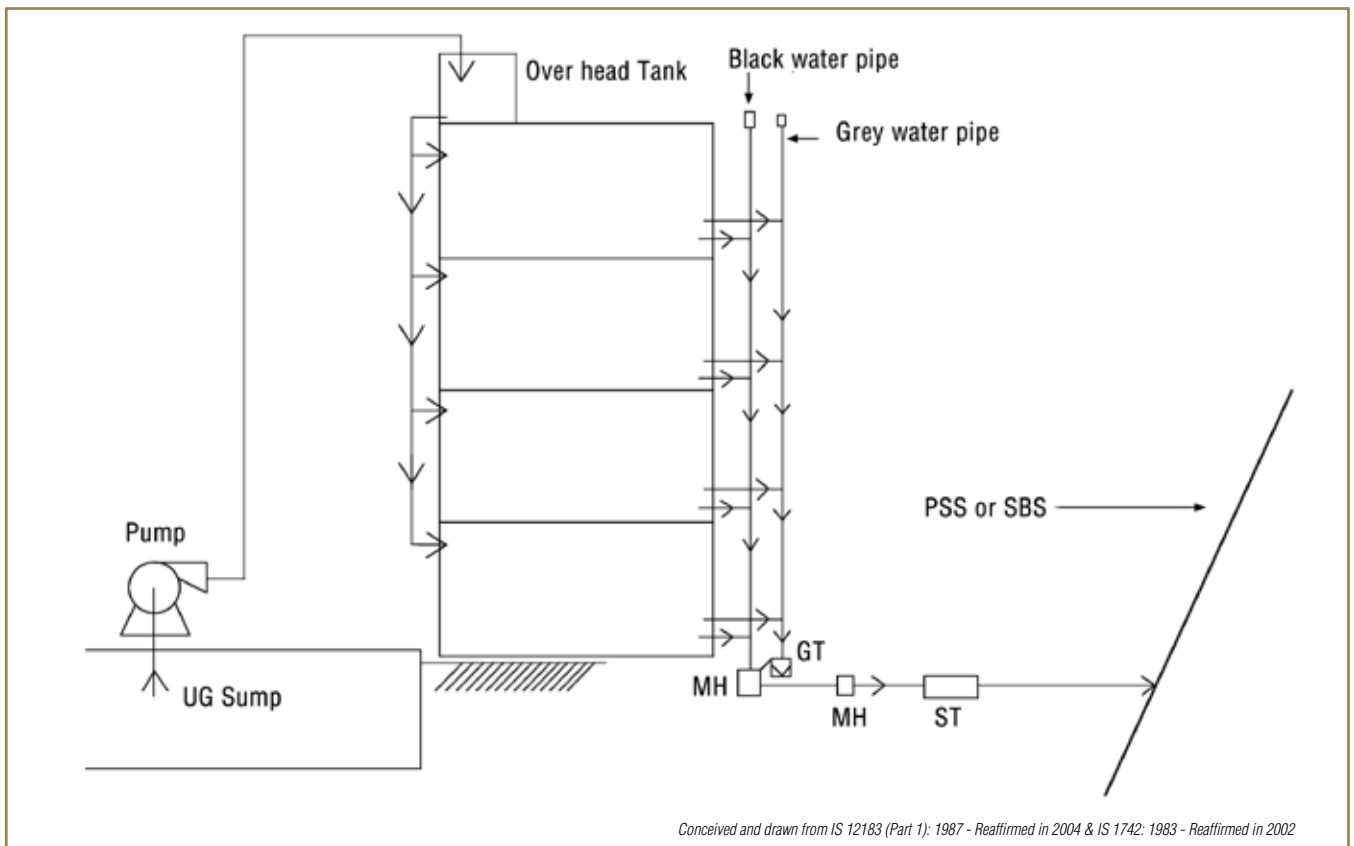


**Figure 40:** Vacuum tanker desludging a septic tank

- The effluent from the septic tank may be connected to Public sewerage system or small bore system as the case may be with the **approval of the authority**.
- In this case as the solids are retained in the septic tank itself and only liquid waste alone is transported to the PSS, the cost of execution will be less.
- A small diameter pipe of 100 mm may be used. But the septic tank will act as a collection tank.

**DID YOU KNOW?**

In the case of interceptor tank, the intercepting tank in principle is a single compartment septic tank. The tank effluent is connected to the SBS/Gravity sewerage system /Simplified sewers instead of connecting to an individual disposal system.



**Figure 41:** Water supply and sewerage system of a building – the drain connected to SBS/PSS through septic tank as interceptor tank

**Field Visit**

As a group, inspect new sewerage commissioned site

Find out what alterations are being made to bypass the Septic Tanks to send the effluents directly into the newly commissioned sewerage.

## ***Notes***

## CHAPTER 4



# Connecting Building Drainage to Septic Tank and Other Decentralised Systems

## Chapter Objective:

- The chapter provides a step by step approach to be followed by a plumber in connecting building drainage system to individual disposal systems. It is recommended in the absence of a public sewerage system.
- It highlights the various types of septic tanks, precautions a plumber has to consider in connecting building drain to septic tank, septic tanks suitable for various terrains and soil conditions, need for certain types of traps, design specification a plumber has to adhere to in a septic tank, right ways to connect various types of pipes and recommendations as prescribed in the national plumbing standards.
- A brief description about the various other decentralised effluent disposal systems such as soak pits dispersion trench, biological filters and mound is also provided.

**Chapter Duration: 180 minutes\***

## SECTION 1: Septic tanks – basic definitions and workings

### Basic definitions

**Septic tank** – refers to a watertight concrete box, buried in the ground just outside the building, but within the premises. Septic tank is a popular type of Individual disposal system for safe disposal of building sewerage in India.

Where public sewerage system is absent, the building drainage is discharged into the Septic tank. It acts as a small-scale sewage treatment system helping in safe disposal of both black and grey water.

Few key points a plumber should follow with respect to septic tanks are:

- Septic tank should be located at an open place and as far away as possible from the exterior wall of the building.
- It **should not be located** in swampy areas or areas prone to flooding.
- It should be located in a place, which is accessible for cleaning.
- Design and layout of septic tank shall be done as per IS 2470 (Part-1):1985 - Reaffirmed in 2001. This is explained in **section 3** of this chapter
- Septic tanks is a form of primary treatment and the discharge from the septic tank should always be connected to appropriate

forms of secondary treatment like soak pit, dispersion trench, wetlands, biological filters , anaerobic filters etc.

### How a septic tank works?

It is important for a plumber to understand how a septic tank works. Basic working principles are listed below:

- Wastewater from building is discharged into the septic tank through a T-shaped inlet pipe.
- Heavy solids settle at the bottom of the tank.
- Lighter solids such as grease, oils and fats, rise to the top and form a scum layer. Solids that are not decomposed remain in the septic tank.
- Bacteria grow in the septic tank and digest the solids and reduce the solids into liquid, fats and grease, and insoluble particles.
- A T-shaped outlet pipe prevents the sludge and scum from leaving the tank and clogging the drain field area.
- A relatively clear waste water flows out of the septic tank through the T-shaped outlet pipe.

#### DID YOU KNOW?

Septic tank uses anaerobic bacteria to digest the septage. Anaerobic bacteria are capable of living or growing in an environment lacking free oxygen.

Wastes containing excessive detergents, grease and disinfectants should not be treated in septic tank as they adversely affect the anaerobic decomposition.

\*duration is only indicative and can be changed based on requirements at different locations

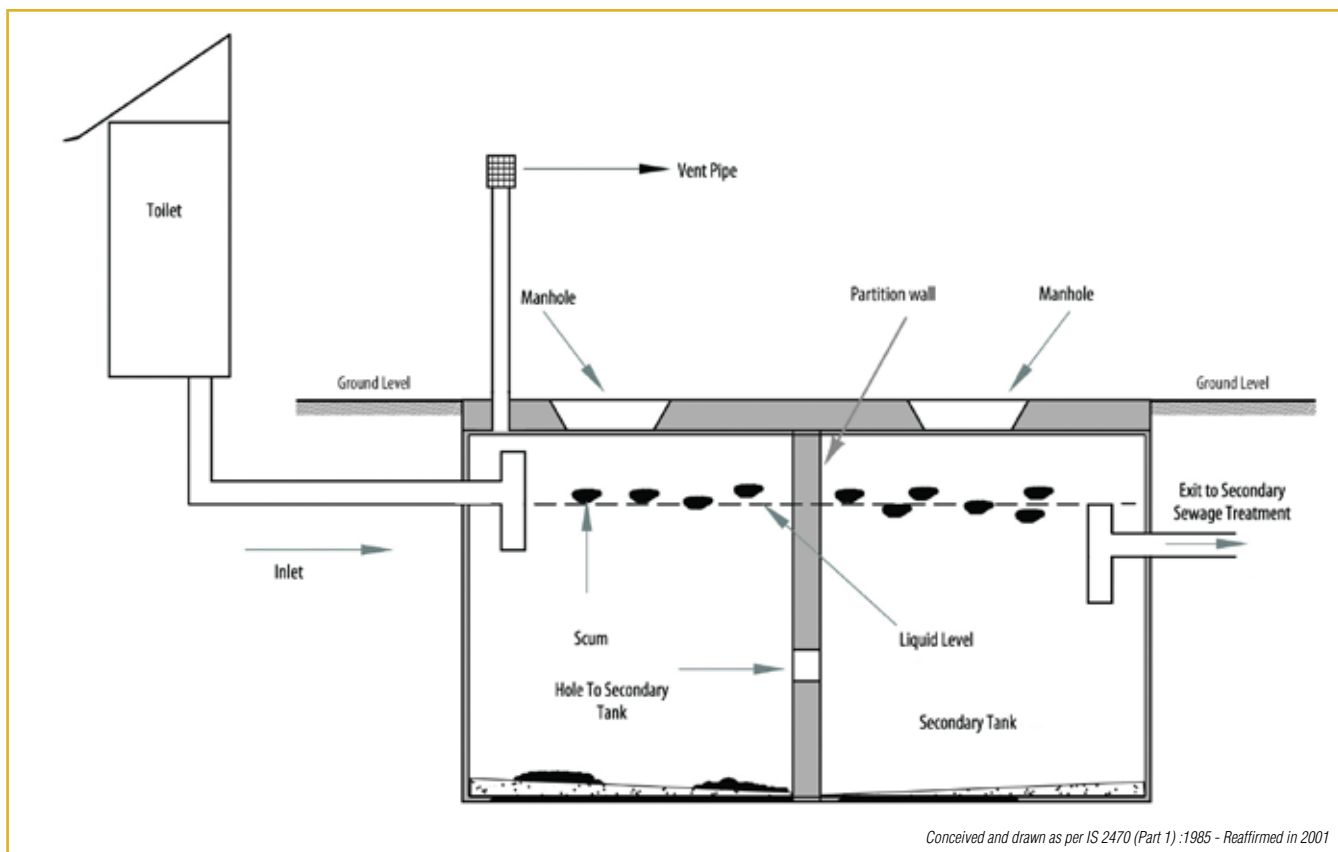
### Tips to plumber to identify a malfunctioning septic tank

#### Around the house

- The grass over the system may become unusually green or spongy to walk on
- Toilets, showers and sinks may take longer to drain
- Occasional sewage odours may become noticeable, often after a rainfall
- You may see gray or black liquids surfacing in your yard, or reversing through plumbing fixtures into the house

#### In lakes and ponds

- Leaks from septic systems can cause weeds and algae to grow in lakes and ponds.
- Just a small amount of additional phosphorus (which can come from soaps, shampoos, household cleaning products and detergents) in a lake or pond can make a huge difference in the amount of weeds that grow during the spring and summer.
- Lakes sometimes develop “dead zones” as a result of an overload of phosphorous – which can lead to too much algae, deplete oxygen supplies and kill fish.



**Figure 42:** Schematic of a septic tank

## SECTION 2: Connecting building drain to a septic tank

### Connecting Building Drain to a Septic Tank – Key Steps:

- Step 1: Collect key details about terrain and number of users in building
- Step 2: Connecting building sewage to a manhole
- Step 3: Connecting manhole to septic tank
- Step 4: Connecting septic tank to external disposal system

#### Step 1: Collect Key Details about Terrain and Number of Users in Building

A plumber should collect the following details before planning the connection between building sewage and septic tank

- Find out the nature of terrain in which the building is located. Check if building is located on a hilly terrain, plan area, high

or low waterlogging area. This will be useful to recommend the type of soil absorption system to be adopted after the septic tank.

- Find out the number of people residing and /or using the building. The plumber based on the number of people should recommend the size and type of septic tank to be constructed.

#### DID YOU KNOW?

Septic tanks are recommended only for small communities and institutions whose contributory population does not exceed 300. For larger communities, provision of septic tanks should be avoided as far as possible. Reference SP35

Number of users	Length (in Meters)	Breadth (in Meters)	Liquid depth in meters	
			cleaning interval - 1 Year	cleaning interval - 2 years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

**Table 4:** Recommended size for up to 20 users

IS 2470 (Part 1):1985 - Reaffirmed in 2001

Number of users	Length (in Meters)	Breadth (in Meters)	Liquid depth in meters	
			cleaning interval - 1 Year	cleaning interval - 2 years
50	5.0	2.00	1.0	1.24
100	7.5	2.65	1.0	1.24
150	10.0	3.00	1.0	1.24
200	12.0	3.30	1.0	1.24
300	15.0	4.00	1.0	1.24

IS 2470 (Part 1):1985 - Reaffirmed in 2001

**Table 5:** Recommended size for residential colonies

Number of users	Length (in Meters)	Breadth (in Meters)	Liquid depth in meters	
			cleaning interval - 1 Year	cleaning interval - 2 years
50	5.0	1.60	1.3	1.4
100	5.7	2.10	1.4	1.7
150	7.7	2.40	1.4	1.7
200	8.9	2.70	1.4	1.7
300	10.7	3.30	1.4	1.7

IS 2470 (Part 1):1985 - Reaffirmed in 2001

**Table 6:** Recommended size for hostels and boarding schools

Note: A provision of 300mm should be made for free board.

The sizes of septic tank are based on certain assumptions. While choosing the size of a septic tank, the exact calculation shall be made.

for population over 100, the tank maybe divided into independent parallel chambers for ease of maintenance and cleaning.

Plumber can use the **Table 5 & 6** to recommend the size/ type of septic tank. The tables are as per specification of IS 2470 (Part 1):1985 - Reaffirmed in 2001.

### Limitations of a septic tank

Because of the unsatisfactory quality of the effluent from the septic tank and also the difficulty in providing a proper effluent disposal system, septic tanks are recommended only for individual homes and small communities and institutions whose contributory population does not exceed 300.

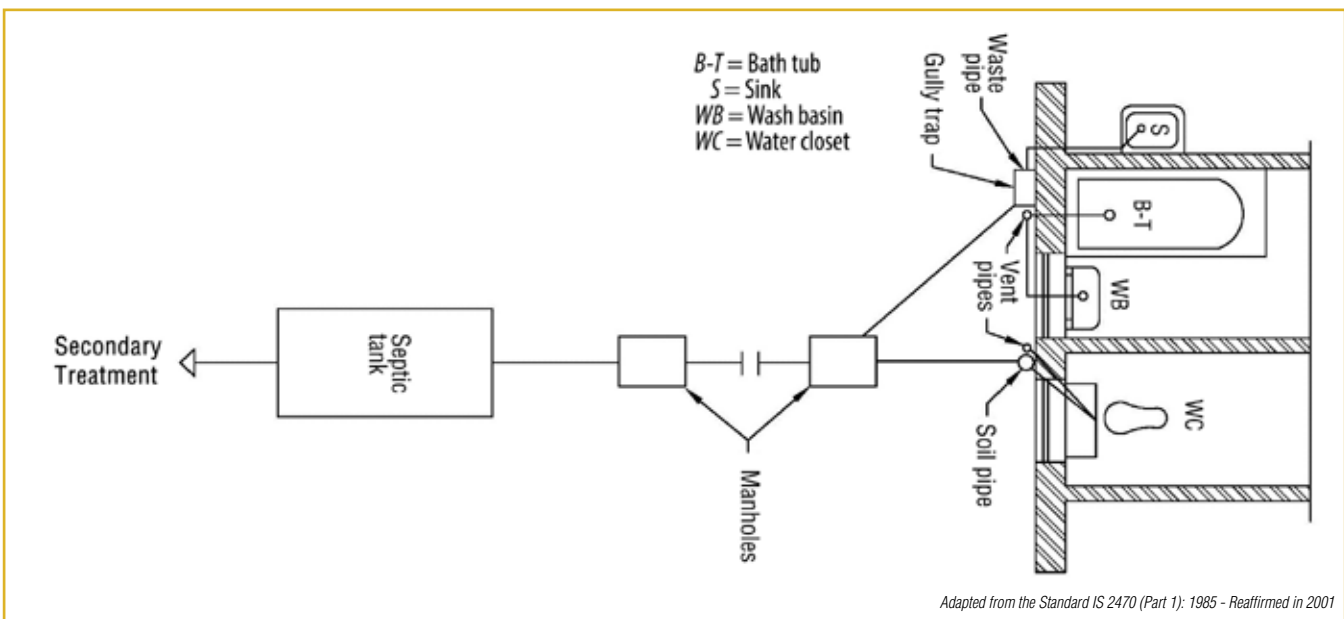
For larger communities, septic tanks may be adopted with appropriate secondary effluent treatment and disposal facilities.

In such cases soak pit (Leech pit is also known as soak pit) is not recommended. The plumber should go in for other secondary treatments.

### Step 2: Connecting Building Sewage to a Manhole

**Material to be used** – Material of the Building Sewer shall be either conventional salt glazed stoneware or UPVC rigid straight pipes of 6 kg/cm<sup>2</sup> pressure class in manufacture and as per IS 15328:2003 with solvent cement joints.

- The building sewage in total is collected in a manhole for conveying to the septic tank for treatment. (Refer to **Figure 43**)



Adapted from the Standard IS 2470 (Part 1): 1985 - Reaffirmed in 2001

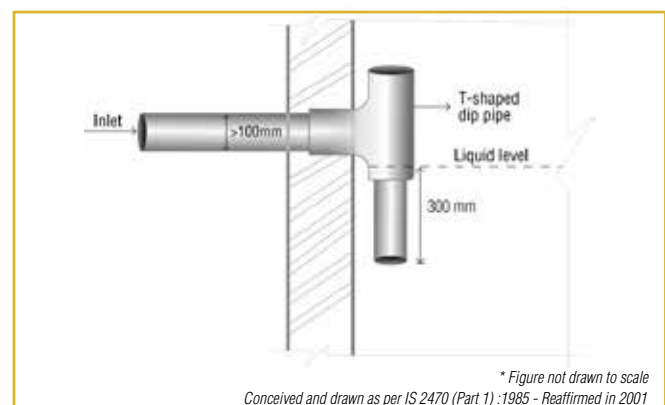
**Figure 43:** Typical layout of a septic tank sewerage system

- The layout should be simple and practical. Pipes should be as straight as possible. Bends should be avoided. Where it is not possible, long radius bends should be used.

### Step 3: Connecting Manhole to Septic Tank

This is the most important connection in this form of disposal and the plumber should follow below mentioned guidelines strictly.

- If the incoming drain is steep due to site conditions, the last section of the drain, at least 12 meters in length should not be laid at a gradient steeper than 1: 50 in order to minimize turbulence in the tank.
- For practical considerations, a minimum nominal diameter of 100 mm is recommended.
- The inlet shall be T-shaped dip pipe to avoid turbulence in the



\* Figure not drawn to scale  
Conceived and drawn as per IS 2470 (Part 1):1985 - Reaffirmed in 2001

**Figure 44:** T shaped dip inlet pipe

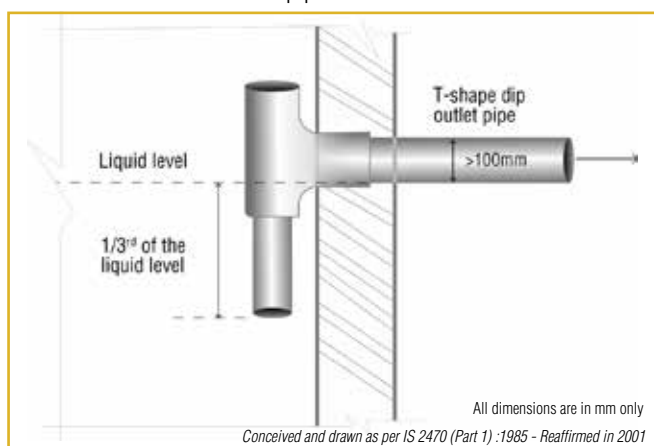
tank. The pipe shall be fixed inside the tank, with top limb rising above scum level and the bottom limb extending about 300 mm below the top water level. Refer to **Figure 44**.

4. When the sewage is pumped to a septic tank, the sewage from the building sewer should be discharged into a small tank and then the sewage is allowed to flow into the septic tank by gravity to avoid turbulence inside the tank.
5. How connections inside a septic tank are made is discussed separately in **Section 3** of this chapter.

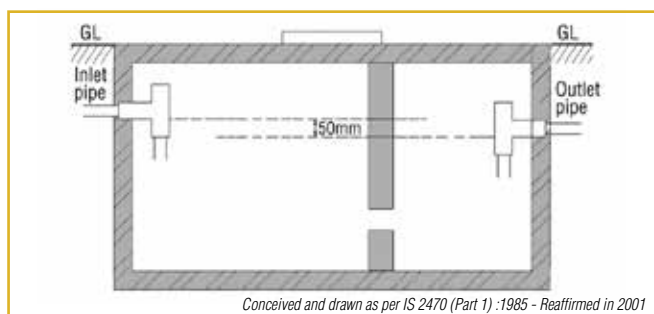
#### Step 4: Connecting Septic Tank to External Disposal System

The plumber should follow the below mentioned steps to connect septic tank to external disposal system.

1. The final outlet for tanks should be at least by 100 mm nominal bore T shaped dip-pipe fixed inside the tank. The top limb of T-shaped outlet pipe should rise above scum level and the bottom limb should extend to about 1/3 of the liquid depth below top water level.
2. The invert of the outlet pipe shall be 50 mm below the invert of



**Figure 45:** T shaped dip outlet pipe



**Figure 46:** Position of invert of inlet and outlet pipe in septic tank

the inlet pipe.

3. IS 2470 (Part 2): 1985 - Reaffirmed in 2001 – recommends following methods to safely dispose effluent from septic tank
  - Soil absorption system – best suitable for plains and where land area is available.
  - Biological filters – best suitable for high water table area and where land is limited.
  - Up flow anaerobic filters – best suitable for high water table area and where land is limited.

### SECTION 3: Construction / connections in septic tanks – plumbers point of view

IS 2470 (Part 1): 1985 - Reaffirmed in 2001 provides design and construction specification for septic tanks. The sizes of the septic tank shall be based on number of users as per the above code. Refer to **Section**

#### Construction/Connection in Septic Tanks

- A. Single Compartment Septic Tank for 20 users
- B. Two compartment septic tank for 50 users
- C. Two compartment septic tank for more than 50 users
- D. Duplicate septic tank for more than 100 users
- E. Precast Septic Tanks

2 of this chapter for recommendations in size of septic tanks.

#### A. Single compartment septic tank for 20 users

As per the IS 2470 (Part 1): 1985 - Reaffirmed in 2001, the sizing of the septic tank is based on the maximum flow in the building sewer is based on number of fixtures in the plumbing system.

##### a. Size:

- A minimum width of 750 mm, minimum depth of 1 m below water level and a minimum liquid capacity of 1000 litres is recommended.
- For rectangular tank, the length shall be 2 to 4 times the width.
- For circular tank - the minimum diameter shall be 1.3 m and the operating depth shall be greater than 1 meter.

##### b. Inlet:

- If the incoming drain is steep due to site conditions, the last section of the drain, at least 12 m in length should not be laid at a gradient steeper than 1: 50 in order to minimize turbulence in the tank
- For practical considerations, a minimum nominal diameter of 100 mm is recommended.
- The inlet shall be T shaped dip pipe to avoid turbulence in the tank. The pipe shall be fixed inside the tank, with top limb rising above scum level and the bottom limb extending about 300 mm below the top water level. Refer to **Figure 44** in this chapter for better understanding.

##### c. Outlet:

The final outlet for tanks should be by 100 mm nominal bore T shaped dip-pipe fixed inside the tank. The top limb of T-shaped outlet pipe should rise above scum level and the bottom limb should extend to about 1/3 of the liquid depth below top water level. The invert of the outlet pipe shall be 50 mm below the invert of the inlet pipe.

##### d. Free board:

A minimum free board of 300 mm should be provided. Refer to **Figure 48** for details.

##### e. Vent pipe:

- Every septic tank shall be provided with ventilating pipe of at least 50 mm diameter. The top of the pipe shall be provided with a suitable cage of mosquito proof mesh.
- The recommended height of the vent pipe should be 2 meters when the septic tank is at least 20 meters away from the nearest building.
- If the septic tank is less than 20 meters from nearest building then the vent pipe should extend at least 2 meters above the highest point of the building.

##### f. Access opening:

- A septic tank shall be provided with a rectangular access opening measuring not less than 455 x 610 mm or a circular opening of 500 mm diameter. The cover should be water tight.

### B. Two compartment septic tank for 50 users

As per the IS 2470 (Part 1): 1985 - Reaffirmed in 2001, the sizing of the septic tank is based on the maximum flow in the building sewer, which is based on the number of fixtures in the plumbing system.

**DID YOU KNOW?**

A portion of sludge not less than 25 mm in depth should be left behind in the tank bottom which acts as the seeding material for the fresh deposits.

- Refer to **section 2** for the recommended size of the septic tank.
- Refer to **section 3** for recommendation on access opening, free board and vent pipe.

**Partitions:**

- Here the tank may be divided into two chambers by means of a fixed durable partition.
- The capacity of the first chamber is two third and that of the second chamber is one third.
- For connecting the two chambers a rectangular or circular opening with minimum dia 100 mm and maximum 150 mm is provided in the partition at approximately 300 mm below TWL.

- The digested sludge should be withdrawn through a dip pipe under a hydrostatic pressure of at least 450 mm. The sludge pipe shall deliver the sludge to the sump and be provided with a delivery valve to draw the sludge as required.
- Portable pumps may also be used for de-sludging
- Manual handling of sludge should be avoided.

**Inlet**

- It is same as septic tank with single chamber.

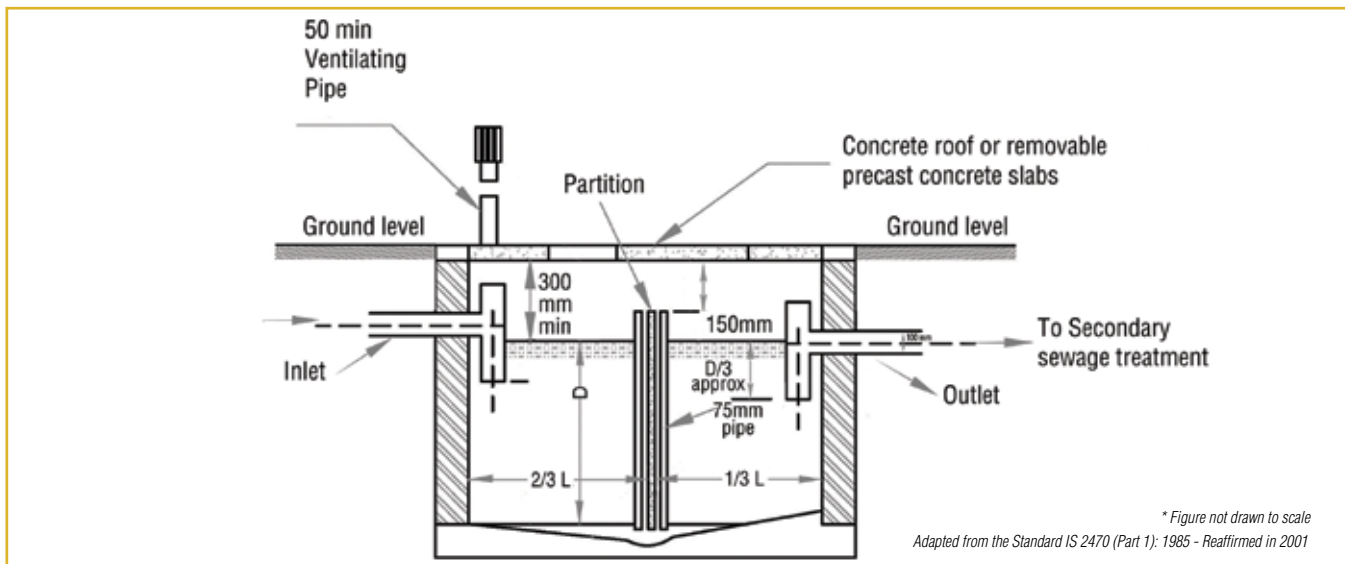
**Outlet**

- It is same as septic tank with single chamber.

### C. Two compartment septic tank for more than 50 users

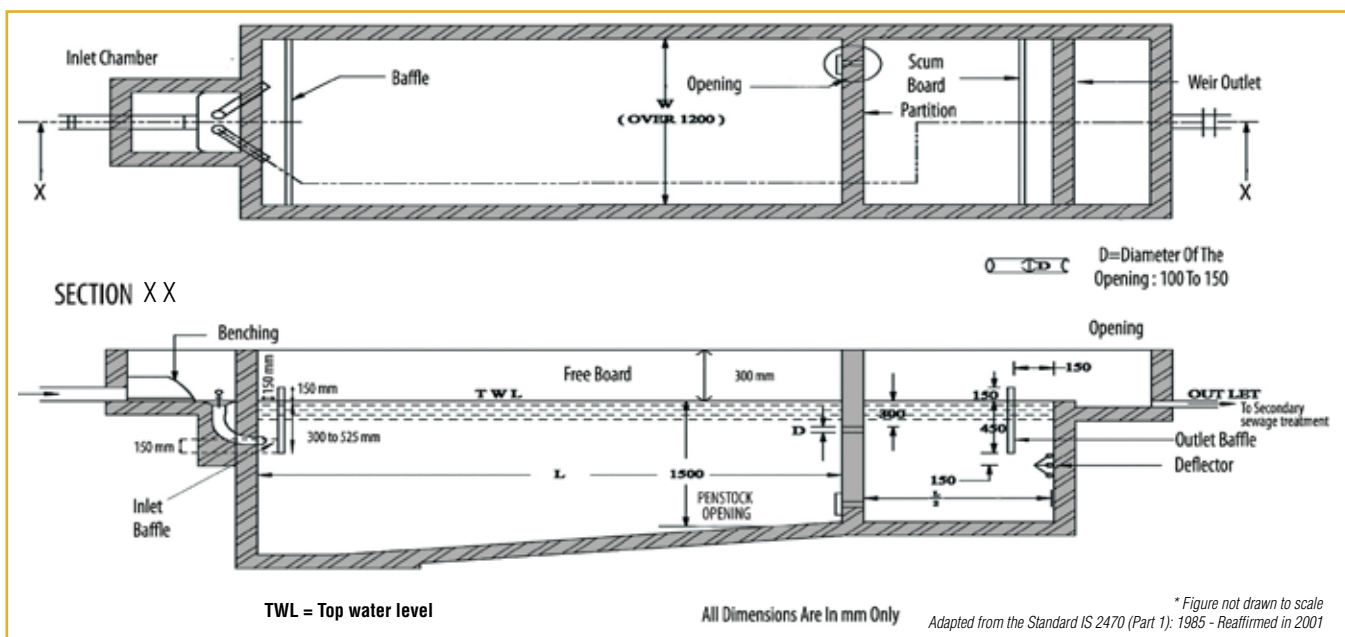
As per the IS 2470 (Part 1) : 1985 - Reaffirmed in 2001, the sizing of the septic tank is based on the maximum flow in the building sewer is based on number of fixtures in the plumbing system

- Refer to **section 2** for the recommended size of the septic tank.
- Refer to **section 3** for recommendation on access opening, free board



\* Figure not drawn to scale  
Adapted from the Standard IS 2470 (Part 1): 1985 - Reaffirmed in 2001

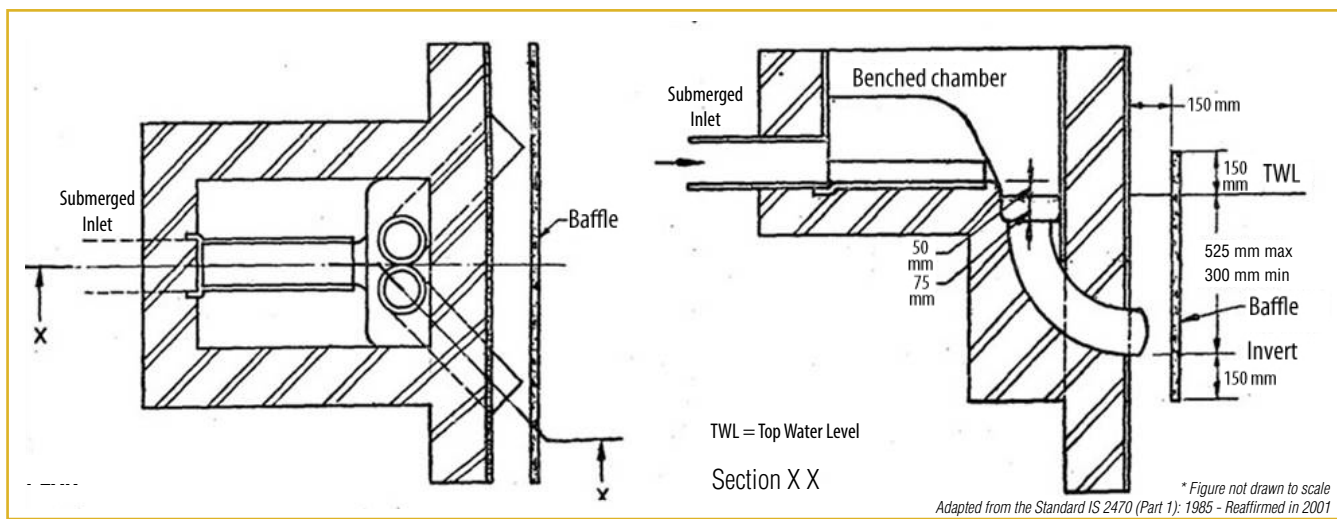
**Figure 47** Typical sketch of two compartment septic tank for population upto 50



\* Figure not drawn to scale  
Adapted from the Standard IS 2470 (Part 1): 1985 - Reaffirmed in 2001

**Figure 48:** Typical sketch of two compartment septic tank for population over 50





**Figure 49:** Twin inlets for septic tank where width exceeds 1.2 m

board and vent pipe and outlet pipe.

- Where the capacity of a septic tank exceeds 2 000 litres, the tank may be divided into two chambers by means of a fixed durable partition.
- The capacity of the first chamber is twice that of the second chamber.

### Inlet

- When the width of the tanks exceeds 1.2 meters, two or more submerged inlets are preferable.
- Submerged inlets are provided by using submerged bends of the same nominal bore (not less than 100 mm) set as closely together as practical in a shallow sump formed within a small benched chamber.
- The invert of the benched channel should be 50 mm above the top water level in septic tank
- The inlet ends of the submerged bends should be set flush with the floor of the sump.
- Floor of the sump should be not less than 75 mm below top water level.
- The inverts of the outlet ends of these bends should be between 300 and 525 mm below top water level in the tank.
- Baffle refers to a flow-directing panel which helps to deflect, check and regulate the flow of sewage and helps reduce turbulence inside the septic tank. It should be provided 150 mm from the inlet end of the tank. It should extend 150 mm below the invert of the inlet pipes and 150 mm above the top water level.
- For wider tanks (more than 2000 litres capacity), it is necessary to use a weir outlet extending the full width of the tank.
- The weir outlet should be protected by a scum board fixed 150 mm from the weir. The top portion of scum board should extend 150 mm above the top water level and bottom portion of scum board should extend to one third (1/3) of liquid depth below the top water level.
- A deflector should be formed either in the structure of the end (outlet) wall or by a purpose-made deflector to prevent rising particles from reaching the outlet weir.

### DID YOU KNOW?

This deflector should be located 150 mm below the base of the scum board and protrude 150 mm into the tank

### D. Duplicate septic tank for more than 100 users

As per the IS 2470 (Part 1): 1985 - Reaffirmed in 2001, the sizing of the septic tank is based on the maximum flow in the building sewer. In

the design of septic tank given below, it is taken as 9 litres per minute.

- For population of over 100, duplicating tanks, each providing half the total calculated capacity required, should be installed and operated in parallel.
- This arrangement permits all the flow to be passed through one unit while the other is being desludged.
- To enable the top water to be decanted when desludging, a decanting valve should be provided in the wall dividing the two tanks; the invert of this valve should be 625 mm below top water level.

### E. Precast septic tanks

Precast Septic Tanks are manufactured in a factory and transported to the site for installation, thereby reducing Installation time and cost considerably. Moreover, the quality of the Septic Tank is also better than Cast-in-situ Septic Tanks as they are manufactured in controlled environments in the factory, thus ensuring water-tightness and material consistency.

Precast Septic Tanks are usually made of Polyethylene or Concrete. They have multiple chambers within them and a manhole for future maintenance. They are available in circular or in rectangular type for



**Figure 50:** Precast concrete septic tank

the capacity required.

### Precast concrete septic tanks in high water table area:

Precast concrete septic tanks are stronger than tanks made of steel, plastic, fiberglass, or high-density polyethylene (HDPE). Precast concrete is flexible enough to withstand extreme loading conditions. Precast concrete gradually strengthens over time. Other products, such as steel or HDPE, can deteriorate and lose strength.



Precast concrete septic tanks are installed in high water table area some times against the buoyant forces. With a specific gravity of 2.40, precast concrete septic tanks resist buoyant forces better than other septic tank materials and hence there will not arise the question of floatation. HDPE has a specific gravity of 0.97 and is more buoyant. Hence additional labor-intensive and time-consuming on-site preparation is needed for anchoring structures made of more buoyant materials.

**Installation procedure**

- i) Make sure that the manhole is on top while lowering the Septic Tank into the dug area.
- ii) Fill the Septic Tank with water completely before fixing the Sanitary Pipes, as a precaution against future settlement due to filled-weight.
- iii) Make sure that there are no stones, gravel or sharp objects below the Poly-ethylene septic tank. Place it on smooth earth. An overflow pipe from the septic tank is to be connected to a Secondary Treatment Unit.
- iv) If the Septic Tank has not been used for a while, fill it up with water by pouring it through the water closet.
- v) Vent-pipe should be raised high from the ground so as to prevent foul smell at normal habitable height.



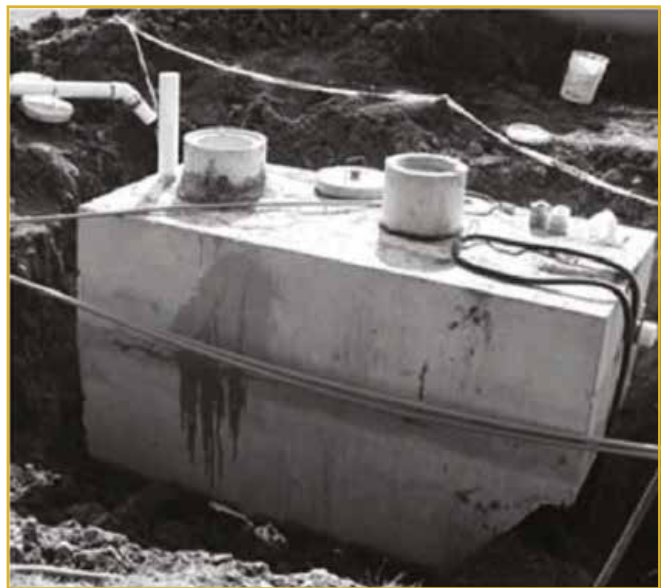
*Adapted from keralaarchitect.blogspot.com*

**Figure 52:** Polyethylene septic tanks



*Adapted from www.lemanprecast.com*

**Figure 51:** Pipe connection to precast septic tank

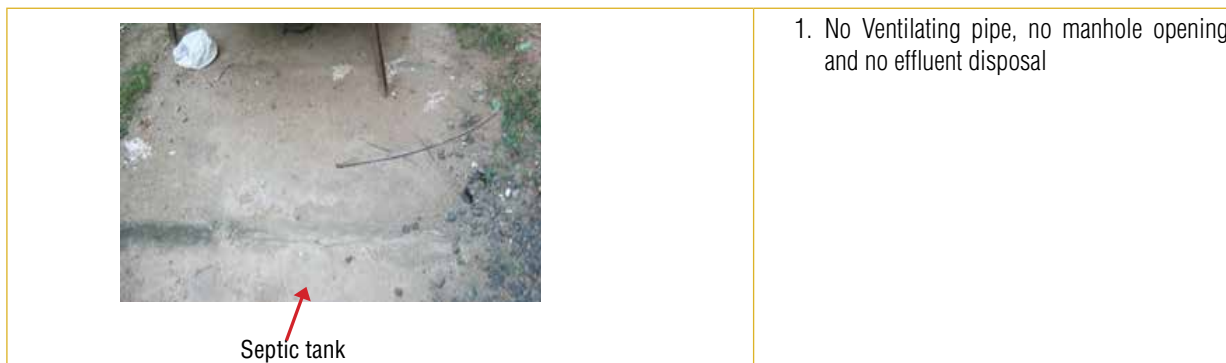


*Adapted from 15217.in.all.biz*

**Figure 53:** Installation of precast septic tank

**Common mistakes done by the plumbers:**

<p>Septic tank Toilet discharge pipe</p>	<ol style="list-style-type: none"> <li>1. Septic tank is not constructed properly, No Ventilating pipe.</li> <li>2. Toilet pipe discharges into a ring well type septic tank and percolates into the earth.</li> </ol>
<p>Waste water line to open drain Soil line to septic tank (through a chamber - line buried)</p>	<ol style="list-style-type: none"> <li>1. The waste water line is connected to the street drain.</li> </ol>



Position of the sub soil water level from ground level	Soil and sub soil conditions		
	Porous soil with percolation rate		Dense and clays soil, with percolation rate exceeding 60 minutes
	Not exceeding 30 minutes	Exceeding 30 minutes but not exceeding 60 minutes	
Within 1.8 m	Dispersion trench located partly or fully above ground level in a mound	Dispersion trench located partly or fully above ground level in a mound	Biological filter partly or fully above ground level with under-drains or up flow anaerobic filter and the effluent led into a surface drain or used for gardening
Below 1.8 m	Seepage pit or dispersion trench	Dispersion trench	Subsurface biological filter with under drains or up flow anaerobic filter and the effluent led into a drain or used for gardening

IS 2470 (Part 2): 1985 - Reaffirmed in 2001

**Table 7:** Recommended method for disposal of septic tank effluent

Note - Where the above mentioned methods are not feasible and where the effluent has to be discharged into open drain it should be disinfected

S No	Percolation rate (Minutes)	Maximum rate of effluent application (l/m <sup>2</sup> / day)
1	1 or less	204
2	2	143
3	3	118
4	4	102
5	5	90
6	10	65
7	15	52
8	30	37
9	45	33
10	60	26

IS 2470 (Part 2): 1985 - Reaffirmed in 2001

**Table 8:** Allowable rate of effluent application to soil absorption system.

Note:

- The absorption area for a dispersion trench is the trench bottom area.
- The absorption area for seepage pits is the effective side-wall area, effective depth being measured from 150 mm below invert level or inlet pipe to the bottom of the pit.
- If the percolation rate exceeds 30 minutes, the soil is unsuitable for soakaways. If the percolation rate exceeds 60 minutes, the soil is unsuitable for any soil absorption system.

## SECTION 4: Effluent disposal

### Methods of treatment and disposal of effluent from septic tank (IS 2470 (Part 2) : 1985 - Reaffirmed in 2001)

#### Soil absorption system

##### Effluent Disposal

Soil absorption system,  
Biological filters,  
Up flow anaerobic filters

##### Do a Percolation Test

Design either Seepage pit/ Leach pit or Dispersion trench/ Drain field  
Determine the trench and sand mound

Plumber can carry out a simple Percolation test to determine the type of soil absorption system suitable for disposal of septic tank effluent.

**Percolation Test** – To decide on the details of a soil absorption system, a soil absorption test is conducted. The percolation rate, that is, time required in minutes for water to fall 25 mm in the test-hole is determined. A test in trial pits at more than one place in the area

should be undertaken to permit deriving an average figure for percolation rate.

**Design of Soil Absorption Systems** – The allowable rate of application of effluent per unit area of dispersion trench or seepage pit is limited by the percolation rate of the soil.

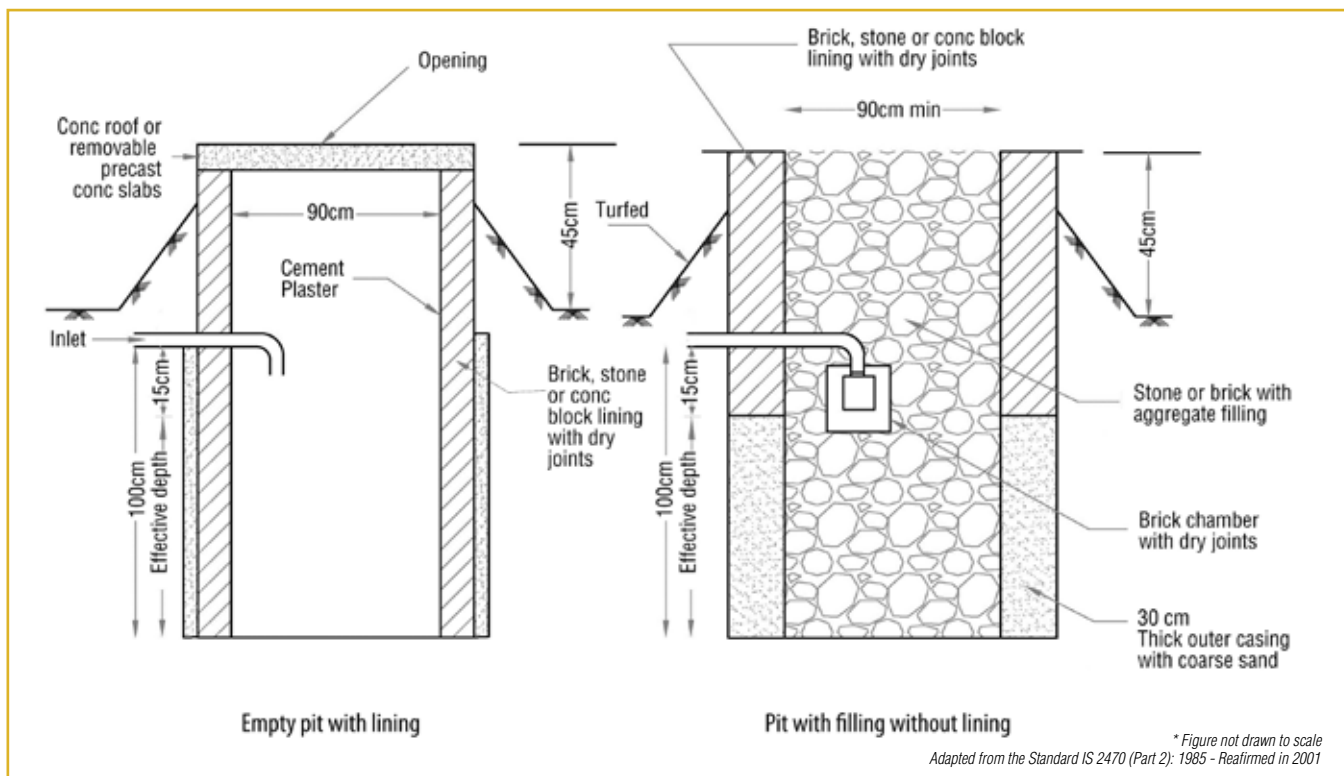
**There are three types of soil absorption system:**

- A. Seepage pit/ Leach pit
- B. Dispersion trench/ Drain field
- C. Secondary Treatment

**Location of Subsurface Absorption System** – A subsoil dispersion system shall not be closer than 18 m from any source of drinking water, such as well, to mitigate the possibility of bacterial pollution of water supply.

### A. Seepage pit/Leach pit

- The seepage pit may be of any suitable shape with the least cross-sectional dimension of 0.90 m and not less than 1.0 m in depth below the invert level of the inlet pipe.
- The pit may be lined with stone, brick or concrete blocks with dry open joints which should be backed with at least 75 mm of clean coarse aggregate
- The lining above the inlet level should be finished with mortar. In the case of pits of large dimensions, the top portion may be narrowed to reduce the size of the RCC cover slabs. Where no lining is used, especially, near trees, the entire pit should be filled with loose stones.
- A masonry ring may be constructed at the top of the pit to prevent damage by flooding of the pit by surface run-off.
- The inlet pipe may be taken down to a depth of 0.90 m from the top as an anti-mosquito measure.



**Figure 54:** Leach pit

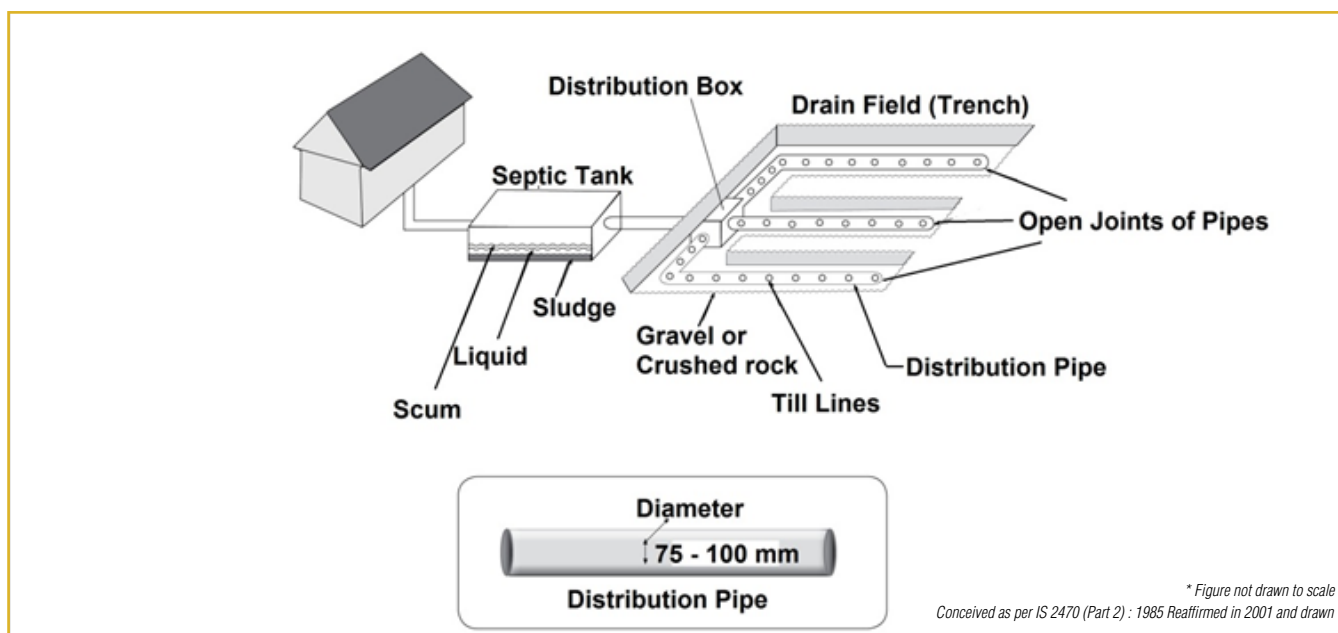
**The plumber should take care of** the gradient, size and the position of the inlet pipe from the pit bottom.

#### The Plumber should take care of the following while laying the pipes in a dispersion trench:

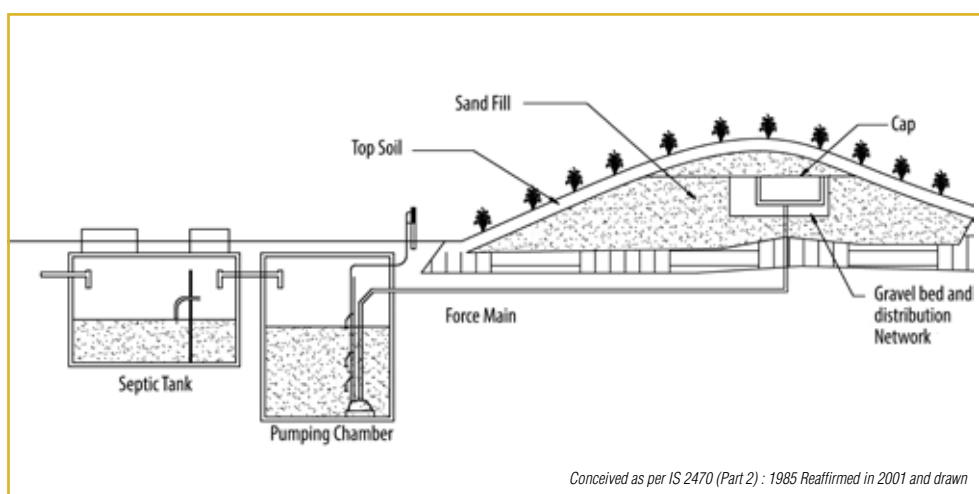
- Open jointing of pipes placed inside the trench.
- The diameter of pipe should be between 75 – 100 mm.
- Light gradient of pipe should be provided for smooth flow of effluent from septic tank to distribution box and then to the trench.

### B. Dispersion Trench

- Dispersion trenches shall be 0.5 to 1.0 m deep and 0.3 to 1.0 m wide excavated to a slight gradient and shall be provided with 150 to 250 mm of washed gravel or crushed stones.
- Open jointed pipes placed inside the trench shall be made of unglazed earthen-ware clay or concrete and shall have minimum internal diameter of 75 to 100 mm.
- Each dispersion trench should not be longer than 30 m and trenches should not be placed closer than 2 m.
- The covering for the pipes on the top should be with coarse aggregate of uniform size to a depth of approximately 150 mm.
- The aggregate above this level may be graded with aggregate 12 to 15 mm to prevent ingress of top soil.



**Figure 55:** Dispersion trench



**Figures 56:** Sand mound

- The trench should be covered with ordinary soil upto 300 mm to form a mound (heap). The mound may be covered with the turf (Grass).
- The finished top surface may be kept at least 150 mm above ground level to prevent direct flooding of the trench during rains.

**Sand mound:** In these systems, the effluent flows from the septic tank to a storage tank. The liquid is then pumped from the tank to per-

rated plastic pipes buried in a mound of sand built on the original soil surface. This system provides a layer of suitable soil thick enough to ensure adequate time and distance for proper treatment of the waste water. Vegetation growing on the mound helps to evaporate some of the liquid.

### C. Secondary Treatment

#### Biological filters

- Biological filters are suitable for treatment of septic tank effluent where the soil is relatively impervious, water logged areas or where limited land area is available. It requires ample ventilation and an efficient system of under drains leading to an outlet.
- The effluent from septic tank is brought into contact with a suitable medium, the surfaces of which become coated with an organic film.
- The depth of medium should be between 900 - 1400 mm and should be retained in position by walls of adequate trench. The filter should have a concrete floor, laid to falls with a system of under drains laid on it and consisting of field drains half channels laid upside down and open jointed, or special tile discharging to the outlet.

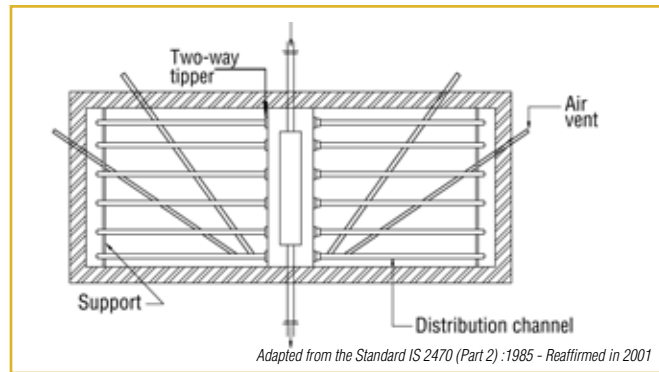
- The septic-tank effluent should be distributed evenly over the surface through which it percolates to the floor. Biological filters may be either rectangular or circular in shape and a series of fixed channels or rotating arm distributor may be used for distributing effluent on the medium.
- Where the filter is below ground level, the vent pipes from the ends of the under drains should be carried to 150 mm above ground level outside the filter.
- Normally the filter should not be covered, but wire netting may be used to prevent falling of leaves fouling the surface of the filter or blocking the ends of the vent pipe.
- The filter effluent is either discharged into surface drain or evenly distributed over a grass plot from the system of channels.
- For populations of up to 10 persons the volume of the filter medium should be 1 m<sup>3</sup> of medium per head, of resident population. For over 10 and up to 50 persons, 0.8 m<sup>3</sup> and for over 50 and up to 300 persons, 0.6 m<sup>3</sup>.

#### Disadvantage of biological filters

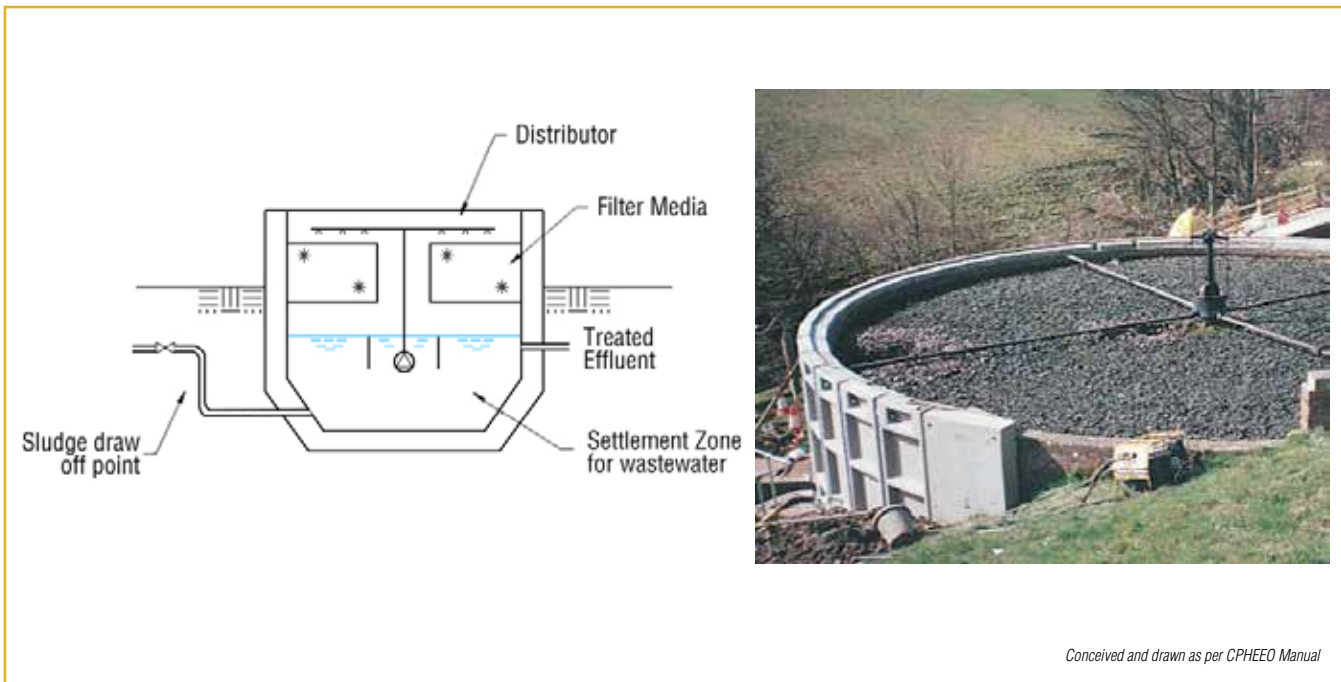
- Medium to High capital cost
- Large land area required
- Clogging danger



- Low volumetric loading rates
- Possible odour problems or high volumes of waste air to be treated
- Lot of excess sludge as byproduct which becomes difficult to dispose.
- High operation cost for
  - aeration (power)
  - sludge disposal



**Figures 57:** Rectangular biological filters



Conceived and drawn as per CPHEEO Manual

**Figure 58:** Circular biological filter

### Up flow anaerobic filters:

These are used in areas where there is dense soil condition, high water table and limited availability of open land.

- The septic tank effluent is introduced from the bottom and the microbial growth is retained on the stone media making possible higher loading rates and efficient digestion.
- The capacity of the unit is 0.04 to 0.05 m<sup>3</sup> per capita or 1/3 to 1/2 the liquid capacity of the septic tank it serves. The effluent is clear and free from odour and nuisance.
- In an up flow filter, the tank effluent enters at the bottom through a system of under drains, flows upwards through a layer of coarse material generally 0.6 to 1.2 m deep and is discharged over a weir or trough at the top. The driving head in the filter, that is, the difference between the water level and the filter may be as low as 25 to 150 mm during normal functioning.

Up flow anaerobic filters are of the following types:

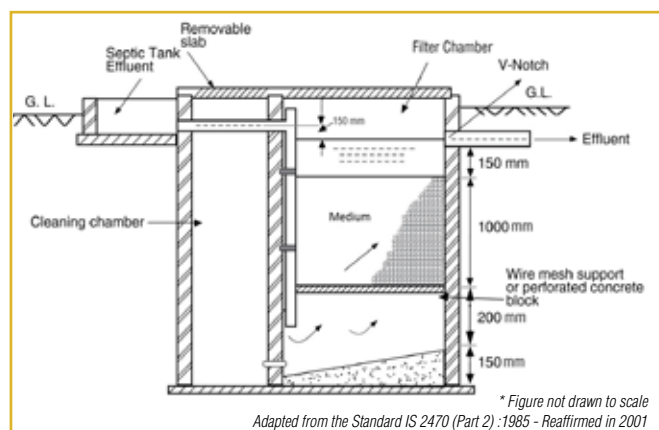
- Single chambered rectangular type,
- Double chambered rectangular type, and
- Circular type.

### The Plumber should take care:

1. Inlet & Outlet pipe with required size and gradient.
2. Providing air vent.
3. Flexible joints may be required on inlet or outlet connections, where rigid pipes are used.

### I. Single chambered rectangular type:

- In this type, a rectangular chamber is constructed to treat the effluent from a normal domestic septic tank.
- The chamber is packed with coarse material and the size of the packing media should be 20 mm.



\* Figure not drawn to scale  
Adapted from the Standard IS 2470 (Part 2):1985 - Reaffirmed in 2001

**Figure 59:** Single chamber rectangular up flow anaerobic filter

- The medium rests on a perforated **concrete false bottom slab**.
- The effluent from septic tank enters the bottom of the filter chamber through a 150 mm pipe and is distributed upward through the media from a perforated slab at the bottom.
- The vertical inlet is fitted with a tee at the bottom, one branch of which leads to the filter and the other branch is kept plugged while the filter functions.
- The plug can be removed to facilitate emptying into an adjoining chamber and cleaning the filter where required.
- The effluent from the top of the bed is allowed to escape over a V-notch whose sill (bottom) level is kept 150 mm above the top of the medium.

## II. Double chambered rectangular type:

### The Plumber should take care:

1. Size and gradient of inlet pipe - T shaped dip pipe.
2. Level of the V Notch – 150 mm above the top of the medium.

- The filter consists of two interconnected compartments.
- The first chamber is filled to a depth of 0.55 m with 20 mm coarse medium.
- The second chamber is filled to a depth of 0.45 m with 20 mm size coarse aggregate.
- The septic tank effluent falls through a perforated tray over the medium in the first compartment and enters the second compartment directly from the bottom.
- The effluent passes up through the medium in the second chamber and escapes over a V-notch placed 75 mm above the top of the medium.
- By this arrangement, the time of travel of the effluent through the filter is lengthened.
- The two chambers are each fitted at the bottom with a 15 mm galvanized iron pipe leading to an adjacent chamber.
- A valve in these pipes allows the filters to be partly desludged into the collecting chamber.

## III. Circular Filter – A circular filter 0.9 m dia may also be constructed.

- Medium of aggregate of uniform size 20 mm should be packed to rest on a perforated concrete slab. The effluent may be made to escape over the top of the medium through equally placed notches along the periphery of the filter.
- The sill level is usually 100 mm above the top of the medium.

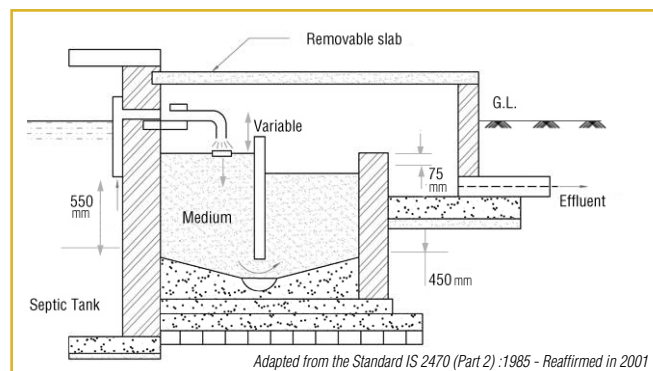


Figure 60: Double chambered rectangular up flow anaerobic filters

### The Plumber should take care of:

- Size and gradient of inlet pipe.
- Level of the V Notch – 75 mm above the top of the medium in the second chamber.
- Providing 15 mm GI pipe with a valve for desludging.

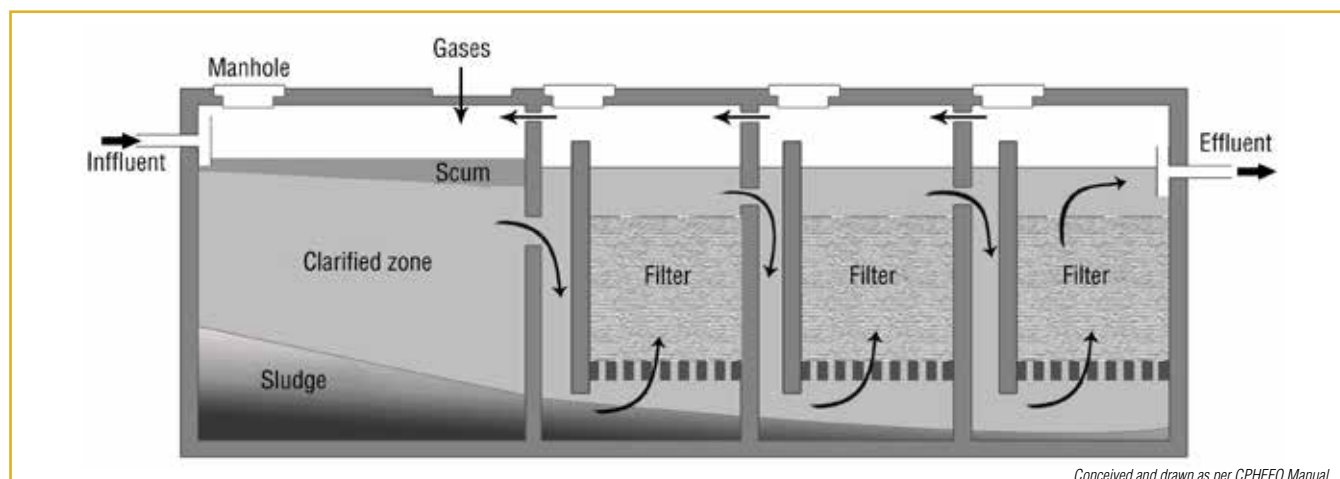
## Multi Chambered Up flow Anaerobic Filters:

Up flow type of filters (reverse filter) operating under submerged conditions is a method for disposal of septic tank effluents in areas where there is dense soil condition, high water table and limited availability of open land. The septic tank effluent is introduced from the bottom and the microbial growth is retained on the stone media making possible higher loading rates and efficient digestion. The capacity of the unit is 0.4 to 0.5 m<sup>3</sup> per capita or 1/3 to 1/2 the liquid capacity of the septic tank it serves. BOD removal of 70 percent can be expected and the effluent is clear and free from odour and nuisance.

This technology consists of a sedimentation tank (or Septic Tank) followed by one or more filter chambers. Filter material commonly used includes gravel, crushed rocks, cinder, or specially formed plastic pieces. Typical filter material sizes range from 12 to 55 mm in diameter. Ideally, the material should provide between 90 to 300 m<sup>2</sup> of surface area per 1 m<sup>3</sup> of reactor volume. By providing a large surface area for the bacterial mass, there is increased contact between the organic matter and the active biomass that effectively degrades it.

Hydraulic Retention Time (HRT) is the most important design parameter influencing filter performance. An HRT of 0.5 to 1.5 days is a typical and recommended.

In this type, the effluent from the septic tank enters at the bottom,



Conceived and drawn as per CPHEEO Manual

Figure 61: Multi chambered up flow anaerobic filters



through a system of under drains, flows up wards through a layer of coarse materials as stated above generally 0.6 – 1.2 m deep and discharge into the inlet of successive chambers. Final discharge is over a weir or trough at the top.

### Baffle reactor septic tank:

**Description:** An Anaerobic Baffled Reactor (ABR) is an improved septic tank because of the series of baffles over which the incoming wastewater is forced to flow. The increased contact time with the active biomass (sludge) results in improved treatment.

The majority of settleable solids are removed in the sedimentation chamber at the beginning of the ABR, which typically represents 50% of the total volume. The up-flow chambers provide additional removal and digestion of organic matter: BOD may be reduced by up to 90%, which is far superior to that of a conventional septic tank. As sludge is accumulated, desludging is required every 2 to 3 years. Critical design parameters include a hydraulic retention time (HRT) between 48 to 72 hours, up-flow velocity of the wastewater less than 0.6 m/h and the number of up-flow chambers (2 to 3).

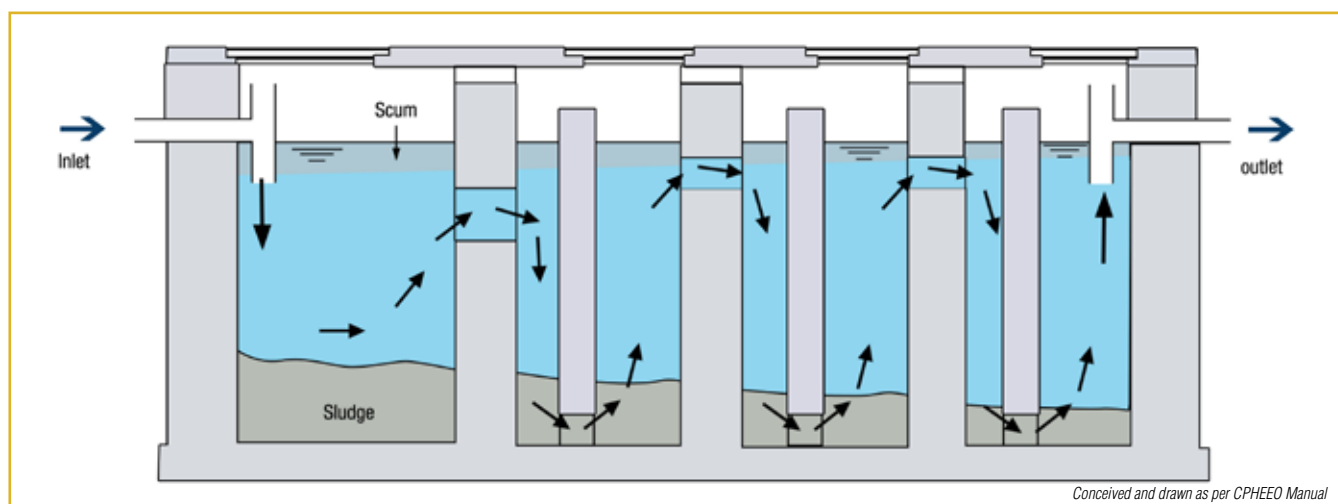
**Adequacy:** This technology is easily adaptable and can be applied at the household level or for a small neighborhood.

This technology is also appropriate for areas where land may be limited since the tank is installed underground and requires a small area.

It should not be installed where there is a high groundwater table as infiltration will affect the treatment efficiency and contaminate the groundwater.

This technology can be efficiently designed for a daily inflow of up to 200,000 L/day. The ABR will not operate at full capacity for several months after installation because of the long start up time required for the anaerobic digestion of the sludge. Therefore, the ABR technology should not be used when the need for a treatment system is immediate.

Because the ABR must be emptied regularly, a vacuum truck should be able to access the location. ABRs can be installed in every type of climate although the efficiency will be affected in colder climates.



**Figure 62:** Baffle reactor septic tank

**Health Aspects/Acceptance:** Although the removal of pathogens is not high, the ABR is contained so users do not come in contact with any of the wastewater or disease causing pathogens. Effluent and sludge must be handled with care as they contain high levels of pathogenic organisms. To prevent the release of potentially harmful gases, the tank should be vented.

**Maintenance:** ABR tanks should be checked to ensure that they are watertight and the levels of the scum and sludge should be monitored to ensure that the tank is functioning well. Because of the delicate ecology, care should be taken not to discharge harsh chemicals into the ABR. The sludge should be removed annually using a vacuum truck to ensure proper functioning of the ABR.

### Advantages:

1. Resistant to organic and hydraulic shock loads
2. No electrical energy required
3. Grey water can be managed concurrently
4. Can be built and repaired with locally available materials
5. Long service life
6. No real problems with flies or odours if used correctly
7. High reduction of organics
8. Moderate capital costs, moderate operating costs depending on emptying; can be low cost depending on number of users

### FIELD STUDY EXERCISE

**Place to Visits:** Visit a septic tank under construction and a septic tank of a multi-storied building.

#### Exercise

- Divide Trainees into groups of 4 people.
- Ask them to prepare a checklist of key items to be inspected in the field visit
- Make each group inspect the septic tanks using their checklist and report findings
- Instructor to use this checklist to educate trainer on what observations were correct and what were not observed at all.

#### Minimum points to check:

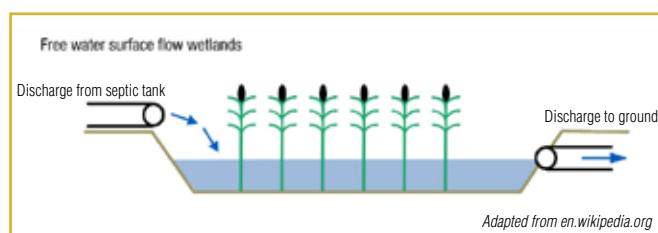
- Required slope for the inlet pipe of a septic tank.
- Provision of vent pipe with cowl and mosquito mesh.
- Height of the vent pipe.
- At junctions of pipes in manholes, how branch connection is made.
- Inlet and outlet – T shaped dip pipe.
- Effluent disposal.

**Disadvantages:**

1. Requires constant source of water
2. Effluent requires secondary treatment and/or appropriate discharge
3. Low reduction pathogens
4. Requires expert design and construction
5. Pre-treatment is required to prevent clogging

**Constructed wetlands:** is a natural, low-cost, eco-technological biological wastewater treatment technology designed to mimic processes found in natural wetland ecosystems.

Constructed wetland is a shallow basin filled with some sort of filter material (substrate), usually sand or gravel, and planted with vegetation tolerant of saturated conditions. Wastewater is introduced into the basin and flows over the surface or through the substrate, and is discharged out of the basin through a structure which controls the depth of the wastewater in the wetland.



**Figure 63 :** Surface flow constructed wetlands

There are 2 types of constructed wetlands

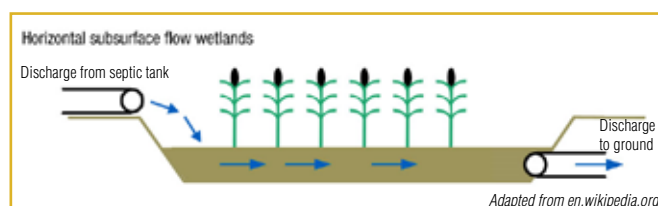
1. **Surface flow constructed wetlands system** – the waste water is distributed on a carefully contoured land with sprinklers. This is more suitable for many types of soil including bay mud and silt clay.

Some characteristics of this type of surface constructed wetlands are

- Large land-area requirements to purify water—20 square meters (220 sq ft) per person
  - Increased smell
  - Poor purification in winter
2. **Sub surface flow constructed wetland** – the waste water is allowed to flow through a gravel or sand medium on which plants are rooted.

There are two types of sub surface constructed wetlands

- **Horizontal flow filters** – waste water is distributed horizontally below the surface and water is allowed to flow between the roots.
- **Vertical flow filters** – waste water is distributed with help of a



**Figure 64:** Horizontal subsurface constructed wetlands

dosing device on 2 or 3 filter beds which are charged alternatively.

**Horizontal subsurface constructed wetlands**

In this type of wetland, wastewater is fed in at the inlet and flow slowly through

the porous substrate under the surface of the bed in a more or less horizontal path until it reaches the outlet zone. During this passage the wastewater will come into contact with a network of aerobic, anoxic and anaerobic zones

Some characteristics of this type of Horizontal subsurface constructed wetlands are:

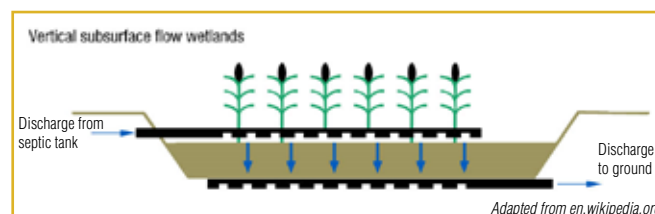
- System is more efficient
- Doesn't attract mosquitoes
- Less odourous
- Less sensitive to winter conditions
- Less area is needed to purify water—5–10 square meters (54–110 sq ft)

**Size of Horizontal wetland system****Warm climate zone**

- For organic loaded sewage (for black and grey water combined), with an average water level of 0.50 m, 3.5 m<sup>2</sup> size is required for 150 Liter discharge
- For black water treatment only, 2 m<sup>2</sup> area is required for 50 L discharge

**Cold climate one**

- For organic loaded sewage (for black and grey water combined), with an average water level of 0.50 m, 7 m<sup>2</sup> size is required for 150 Liter discharge



**Figure 65 :** Vertical subsurface constructed wetlands

**Vertical subsurface constructed wetlands**

This type of wetland comprises a flat bed of sand/gravel topped with sand/gravel and vegetation. Wastewater is fed from the top and it gradually percolates down through the bed before it is collected by a drainage network at the bottom.

Some characteristics of this type of vertical subsurface constructed wetlands are

- Requires less space than Surface wetlands
- Dependent on an external energy source
- Increased efficiency requires only 3 square meters (32 sq ft) of space per person

**Quick Test: To recap the key points in the chapter.**

Tick the correct answer

	<i>Option A</i>	<i>Option B</i>
Septic tank should be located at a place	Inside the building	away from the building
Sewage flow to a septic should be	Smooth/laminar	Rough/turbulent
In case of a rectangular tank, the length	Shall be 5 times the width.	Shall be 2 – 4 times the width.
Lighter solids that float such as grease, oils and fats, rise to the top	and form sludge layer	and form a scum layer
The inlet shall be T shaped dip pipe	to create turbulence in the tank.	to avoid turbulence in the tank.
A minimum free board of	300 mm should be provided.	400 mm should be provided.
Every septic tank shall be provided with ventilating pipe of	at least 50 mm diameter	at least 75 mm diameter
In a two chamber septic tank the capacity of the first chamber is	Thrice that of the second chamber.	Twice that of the second chamber.
Septic tanks are recommended only for small communities and institutions whose contributory population	does not exceed 400	does not exceed 300
Effluent from the septic tank shall be disposed off by	Biological filters	Soil absorption system

**Case study****Connecting building drainage to septic tank and Other Decentralised Systems**

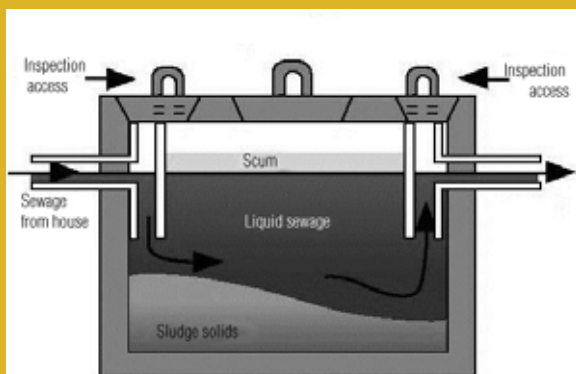
**Aim of the Cases** – The aim of the 2 cases listed below is to highlight the various standards / procedures established for connecting households to septic tank and connecting septic tank to individual disposal system plumbing in a building. In case study 1 a schematic diagram of the cross section of septic tank is to be used to elicit the trainees to identify various standards / parameters set for septic tanks and to highlight what are common areas of violations by plumber. In case study 2 – schematic diagram of an individual disposal system is to be used, to highlight the environmental impact the set up could have if it is not planned correctly.

**Time allotted:** 20 minutes / Case

**Instruction to Trainer** – The case is to be discussed at the end of a training session of a chapter. This will serve to recollect key concepts learnt, bring out the level of understanding of trainees and emphasize the real impact behind theoretical concepts.

The trainer will show the Figure to the trainees and explain the various components visible in the Figure to the trainees. Alternatively, one or more of the trainees could be invited to describe the various components visible in the Figure. Then the case is open for discussion for 10 to 15 minutes. The trainer should use a flip chart or board to capture key points of discussion. Finally the trainer is to summarize the discussion and explain the impact wrong connection depicted in photographs would have.

This will create a lasting impression / retention among the trainees.

**Case study 1****Open to trainees for their inputs and comments**

Trainer's case discussion – key points:

1. No vent pipe.
2. The invert level of outlet pipe must be 50 mm lower than the invert of inlet pipe. (IS 2470 (Part 1): 1985 - Reaffirmed in 2001)
3. Only the liquid effluent is passed out.
4. The bottom limb of inlet pipe should be extended up to 300 mm below the top water level.
5. The bottom limb of outlet dip pipe should be 1/3 of liquid depth below top water level.
6. Floor - A minimum slope of 1:10 should be provided towards the sludge outlet to facilitate desludging.
7. A free board of 300 mm should be provided.

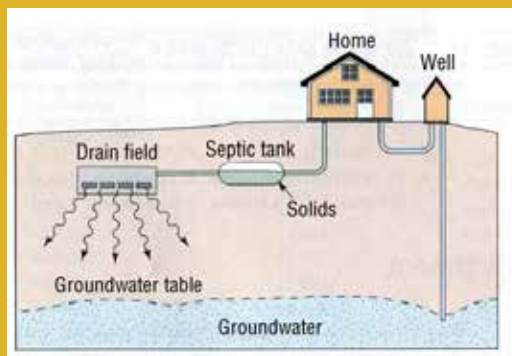
**Case study 2**

Figure depicting septic tank with dispersion trench

**Open to discussion among all trainees**

Trainer's case discussion – key points:

1. Understand the possibility of drinking water getting polluted by the proximity of dispersion trench.
2. Explain the health impact it could have on people.

**Case Study**

## ***Notes***

## CHAPTER 5

# Sewerage Connections – High Altitude and High Water Table Terrain

## Chapter Objective:

- The chapter highlights the additional details that a plumber should know in connecting building sewage to public sewerage system or septic tank in areas of high altitudes and in areas of high water table.

### Chapter Duration: 120 minutes\*

#### SECTION 1: Terrain conditions

In any building, the sewage generated should be disposed safely without disturbing the environment.

Where public sewerage system is available, the house drain is connected to the public sewerage system with the approval and as directed by the authority.

Where discharge into a public sewer is not possible, the drainage of the building is to be done through any of the individual disposal systems, the predominant being the septic tank.

Though the method of connecting the household sewage either to the sewerage network or to the septic tank is similar to plains (as explained in **Chapter 2** and **3**), plumber needs to take into consideration certain additional care to address problems posed by the nature of terrain.

#### SECTION 2: High altitude / sub zero regions

##### Impact of high altitude on sewage disposal systems

In high altitudes and /or sub-zero temperature regions the tempera-

ture can reach below 4°C and atmospheric pressure could reach below 0.086 N/Sq.mm

The low pressure and temperature will affect the property of water, chemicals, microbes (bacteria) and pumping. This will pose challenges to normal working of a sewerage system and septic tanks.

#### Effect of low temperatures

##### Effect of low temperature

- Physical effect on water
- Behaviour of chemicals
- Biological Impact

**A. Physical effect on water** – Low temperature will have following impact on water

- Water reaches its maximum density at 4°C.
- Water crystallized into ice at 0°C and its volume will expand by approximately one-twelfth.
- The viscosity of water and liquids increases with falling temperatures thus affecting the settling velocities of particles carried in sewage suspension.

**B. Behaviors of chemicals** – Low temperature will have following impact on chemicals

- Most chemicals react much slower at lower temperature (freez-

\*duration is only indicative and can be changed based on requirements at different locations

ing temperature) than they do at normal temperatures.

- As a result, longer reaction times are required for satisfactory performance in the sewage / grey water treatment units, where chemicals are used.

**C. Biological impact** – Low temperatures will have following impact on microbes (bacteria)

- For every 10°C fall in temperature, the biological activity of microbes reduces by 50%.
- As a result sewage decomposition processes in a septic tanks, which depend on biological activities of micro-organisms are affected (slower).

**DID YOU KNOW?**

Effect of Low Pressure

- Low pressure limits the pump suction.

**Tips for plumbers – at high altitude region**

The Plumber should follow the instructions to counter the challenges created by low temperature and pressure

**Plumber should look into**

- A. Sewerage work
- B. Septic Tank
- C. Seepage Pit
- D. Insulation
- E. Tips to Handle Gradient Pressure in Pipes
- F. Tips to measure slope in a terrain

**A. Sewerage works:**

- All sewers should be laid below the frost line (at least 1.2 meters below the ground level).
- Intercepting traps if any should be located below the frost line.
- Manholes should be made air-tight to prevent the cold air from entering the manhole and freezing the sewage.
- The trenches for sewers shall be loosely filled with earth after laying sewers since loose soil is a better insulator than compacted soil.
- Adequate insulation should be done for sewer which needs to be laid under traffic ways and other places, where soil compaction is expected.
- Where ever feasible, sewers shall be so located in such a way that the trench line is not in shadow, when the sun is shining.
- Adequate insulation should be provided to concrete, cast iron and stoneware pipe as they conduct heat (and cold) relatively rapidly.
- Lavatories and bath rooms shall be kept heated to avoid freezing of water inside the traps and flushing cisterns.

**B. Septic tanks** – Septic tanks can function normally only when contents inside do not freeze during low temperature. Plumber should follow the below points to ensure the normal functioning of septic tank

- The septic tanks should be located well below the frost line.
- The location of manhole opening shall be marked by staves.

- Fencing around the septic tanks shall be provided for discouraging traffic over it.
- Plumber should follow the recommend size of septic tanks to ensure normal biological activity. This action is taken to counter the lower biological activity at lower temperature.

Number of users	Length (in Meters)	Breadth (in Meters)	Liquid depth in meters	
			cleaning interval - 1 Year	cleaning interval - 2 years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

IS 2470 (Part 1):1985 - Reaffirmed in 2001

**Table 9:** Recommended size of septic tank at 20 °C

Number of users	Length (in Meters)	Breadth (in Meters)	Liquid depth in meters	
			cleaning interval - 1 Year	cleaning interval - 2 years
5	3	0.75	1.0	1.05
10	3.6	1	1.0	1.40
15	3.6	1	1.3	2.00
20	3.9	1.3	1.3	1.80

This table is derived from Table 5 of IS 2470 (Part 1) : 1985 as per Clause 5.5.2 IS 6295 : 1986

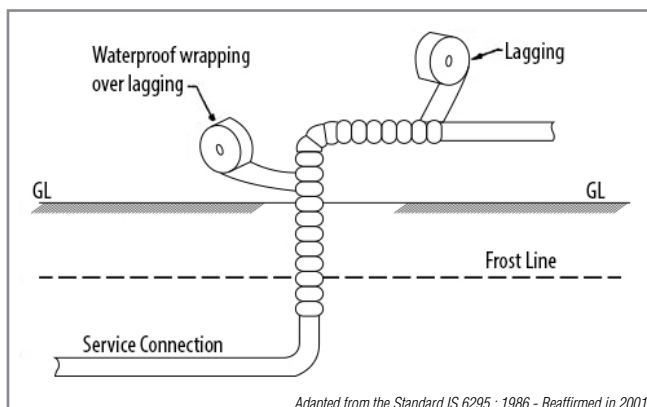
**Table 10:** Recommended size of septic tank at 10 °C

**C. Seepage pits**

- Seepage pits can function only when the soil and sub-soil conditions are favorable. Frozen soil extending to a great depth would preclude the use of such disposal devices in view of the lower water absorption capacity.
- The discharge of effluent should be made below the frost line.

**D. Insulation:**

- **Materials for Insulation of Pipes** – The normal practice in India is to surround the pipe with straw, grass, hessian cloth/ strip or jute wrapped over with gunny and painting with bitumen; alternatively other materials like 85 percent magnesia, glass wool or asbestos coated lagging ropes may also be used.
- A extra layer of mulch (200 – 300 mm) over the pipes, tank and soil treatment system will provide extra insulation. This mulch could be straw, leaves, hay or any other loose material that will not compact and stay in place.
- IS 6295:1986 - Reaffirmed in 2001 recommends Asbestos Lag-



**Figure 66:** Insulation of pipes



- ging Rope, glass wool, hessian cloth for insulation of pipes.
- VML (Trade Name) pipes as a compound pipe system: Insulated pipe system made of socketless cast iron drainage pipes and fittings, with integrated thermal insulation and protection against condensation.
- Socketless cast iron drainage pipes and fittings, are manufactured as per EN 877, dimensions as per DIN 19 522.

### E. Tips to handle gradient water pressure

In hilly areas while connecting house drain to the septic tank, if the incoming drain is steep due to site conditions, the last section of the drain, at least 12 m in length should not be laid at a gradient not steeper than 1: 50 in order to minimize turbulence in the tank.

If gradient / slope is steeper than 1: 50

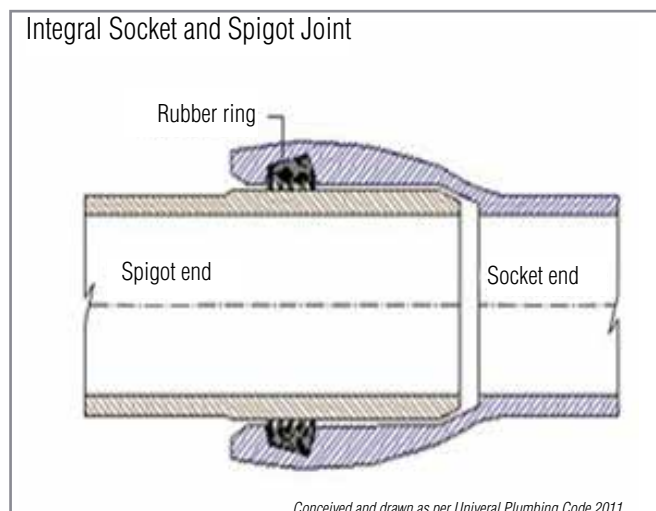
- First discharge the steep drain into a small sump/pit
- then the sewage is allowed to flow in to the septic tank

Also ensure

- Pipe joints should be very tight. Elastomeric seal joint is recommended.
- Joint separation can be prevented in below ground applications by incorporating concrete anchor blocks at appropriate places.
- In above ground applications, anchor blocks must be provided.

### Integral elastomeric sealing ring joints (Rubber Ring Joint):

Elastomeric sealing ring joint consists of an elastomeric sealing element located in the groove in the socket formed integrally with the pipe or fitting. The sealing element (sealing ring) is automatically compressed to form a pressure tight seal when the spigot of the pipe is



**Figure 67:** Elastomeric sealing ring joints

inserted into the socket.

Elastomeric sealing rings are usually made from synthetic materials like Ethylene Propylene Diene Monomer-Rubber (EPDM), Styrene Butadiene Rubber (SBR) or a combination of synthetic and natural rubber. The material should conform to IS 5382:1985 - Reaffirmed in 2003.

### F. Tips to measure slope in a terrain

In case of hilly terrain where natural undulations are expected, in the laying of pipeline to maintain the slope, the following may be adopted:

1. Using levelling instrument, find the RL (reduced level) at the starting point. (*Assume to be 100*)
2. Calculate the trench bottom level with reference to this level. (*Assume to be  $100 - 1 - 0.1 - 0.15 = 98.75$ , 100 mm dia pipe, 150 mm bedding*)
3. Calculate fall with reference to the slope and distance. (*Assume to be 0.3 m*)
4. Calculate level at the bottom of the trench at the end point (*in our case it is  $98.75 - 0.3 = 98.45$* )
5. Using levelling instrument find the RL at the end point.
  - Case 1: The terrain is downward trend: Then the reduced level will be less than at the starting point. Say it is 99.5. Depth of excavation required is  $99.5 - 98.45 = 1.05$*
  - Case 2: The terrain is upward trend: Then the reduced level will be greater than at the starting point. Say it is 100.5. Depth of excavation required is  $100.5 - 98.45 = 2.05$*
6. Use the string and the boning rod to fix the bottom of the trench at the end point.

#### Field Visit

Next time you are on a vacation to a hill station make a trip to the local sewerage plant and analyse if the installations are in line with the Indian Standards

#### Group visit

As a group, organise a trip to a hill station to understand the functioning of the various types of installations in the local sewerage treatment plant

## SECTION 3: High water table area

### Impact of high water table area

The Plumber should follow the listed instructions to counter the challenges posed by high water table zone

#### High Water Table

- A. Connecting building drain to public sewerage
- B. Septic Tanks

#### A. Connecting building drain to public sewerage

In high water table area, during excavation to lay pipes, plumber will encounter problems of oozing of water. This water should be physically bailed out; pumps can be employed if required.

During the rainy season the water table is very high and it will not be conducive to dig trenches to lay the pipes. So Plumbers should work preferably during the dry season.

#### B. Septic tanks

The problem posed by oozing of water during excavation for septic tank need to be countered.

During the rainy season the water table is very high and the plumbers should work choose the dry season to construct septic tank.

The effluent disposal cannot be done by conventional methods (leech pit and drain field). One of the following methods can be adopted for the effluent disposal from septic tank.

- Biological filters
- Up flow anaerobic filters
- Sand mound

**Quick Test: To recap the key points in the chapter.**

Tick if the statements are true or false

	True	False
High Altitudes - Elevations higher than 500 m above mean sea level (MSL)		
Frost Line - The line joining the points of greatest depths below ground level up to which the moisture in the soil freezes		
Lavatories and bath rooms shall be kept cool to avoid freezing of water inside the traps and flushing cisterns		
The septic tanks shall be located well below the frost line		
In high altitude area, the septic tank capacity shall be increased by 50 % for operation at 10°C over that for operation at 20°C		
Materials for Insulation of Pipes - Surround the pipe with straw, grass, hessian cloth/strip or jute rapped over with gunny and painting with bitumen		
Sand mound: Suitable for high water table area		

## Case study:

### Sewerage Connections – High altitude and High water table Terrain

**Aim of the Cases** – The aim of the 2 cases listed below is to highlight the special instructions a plumber has to consider while laying out septic tanks in high altitude and high water table terrain. Photograph will be used to highlight the violations made by plumbers in connecting building drainage to Septic tank and the key points that needs to be considered in this special terrain. In case study 2 – the schematic diagram will be used to highlight key concepts of a sand mound disposal system.

**Time allotted:** 20 minutes / Case

**Instruction to Trainer** – The case is to be discussed at the end of a training session of a chapter. This will serve to recollect key concepts learnt, bring out the level of understanding of trainees and emphasize the real impact behind theoretical concepts.

The trainer will show the photographs to the trainees and explain the various components visible in the photograph to the trainees. Alternatively, one or more of the trainees could be invited to describe the various components visible in the photograph. Then the case is open for discussion for 10 to 15 minutes. The trainer should use a flip chart or board to capture key points of discussion. Finally the trainer is to summarize the discussion and explain the impact wrong connection depicted in photographs would have.

This will create a lasting impression / retention among the trainees.

Case Description – key points:

1. A septic tank in high altitude area.
2. Two manholes provided.
3. One vent provided.
4. Effluent disposal arrangements not provided.
5. The inlet pipes are coming from an elevation and are steep.

## Open to trainees to comment

### Case study 1

Trainer's case discussion – key points:

1. In as much as this is a high altitude area (1500 m above the MSL) the septic tank should be constructed below the frost line. (IS 6295:1986 - Reaffirmed in 2001)
2. The location of the manhole openings shall be marked by staves.
3. Manholes should be air tight to prevent cold air entering.
4. Fencing around the septic tanks shall be provided for discouraging traffic over it.
5. If the inlet pipes are steep (coming from an elevation), the last section at least 12 m in length should not be laid at a gradient not steeper than 1 in 50 in order to minimize the turbulence in the tank.

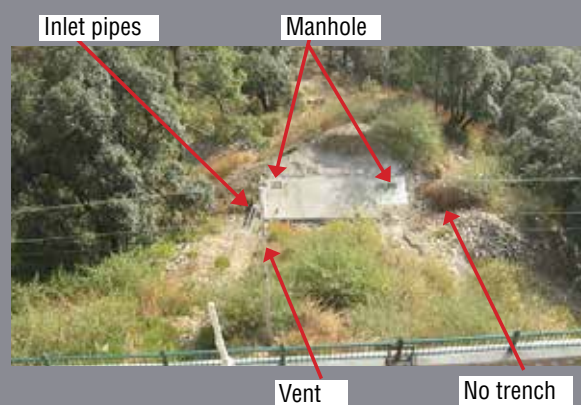


Figure at a High Altitude Terrain

## Case Study

**Case study 2****For interaction with the trainees**

Questions to be answered:

1. What does the Figure represent?
2. Is the area suitable for adoption?
3. What are the special components involved?

Trainer's case discussion – key points:

1. This is a sand mound system for the disposal of effluent from a septic tank.
2. Suitable where the soil percolation rate is poor, Soil with high clay content, ground is already saturated with water etc.
3. Special components:
  - A pumping chamber with a pump adjacent to the septic tank
  - A pipe line to convey the effluent to the mound
  - A sand mound constructed with pile of sand and gravel above ground

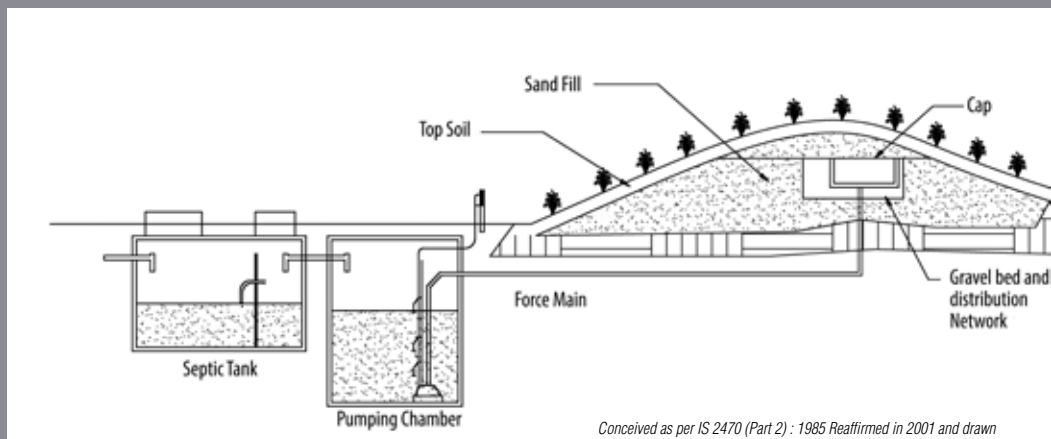


Figure of a sand mound system

## Case Study

## ***Notes***

## CHAPTER 6

# Manual Scavenging and Occupational Health & Safety

## Chapter Objective:

- The chapter discusses the practice of Manual scavenging, the recently passed parliamentary act against manual scavenging.
- The chapter also discusses about occupational health and safety issues with reference to plumbing.

## Chapter Duration: 30 minutes\*

### SECTION 1: Manual scavenging

Manual scavenging refers to the removal of human waste/excreta (night soil) from unsanitary, “dry” toilets, i.e., toilets without the modern flush system. Manual scavenging involves the removal of human excreta using brooms and tin plates. The excreta are piled into baskets which scavengers carry on their heads to locations sometimes several kilometers from the latrines.

### SECTION 2: The bill

As manual scavenging involves issues like dignity and health hazards, Govt had enacted the Employment of Manual Scavengers and Construction of dry Latrines (Prohibition) Act, 1993. It served as a primary instrument to eradicate the practice of manual scavenging.

The Prohibition of Employment as Manual Scavengers and Their Rehabilitation Bill, 2012, was passed by the Parliament on 07.09.2013. The bill is aimed at eliminating of dry latrines and manual scavenging and the rehabilitation in alternate occupations of those engaged in this task.

In the bill, the definition of manual scavenger has been widened to include a person engaged or employed for manual cleaning of human excreta in an insanitary latrine or in an open drain or pit, a drain carrying sewage, sewer and on railway tracks etc.

There are more stringent penal provisions for contravention of the act  
\*duration is only indicative and can be changed based on requirements at different locations



**Figure 68 A:** Woman engaging in manual scavenging

and to set up vigilance and monitoring committees at the sub-division, district, state and central levels.

### SECTION 3: Salient features of the bill:

1. Prohibition of manual scavenging and rehabilitation of manual scavengers;
2. Prohibition of insanitary latrines, which include such latrines where human excreta needs to be cleaned or other-wise handled manually;
3. The definition of manual scavenger has been widened to include a person engaged or employed, inter alia, for manual cleaning of human excreta in an insanitary latrine or in an open drain or pit, railway tracks etc.;



4. Express provisions for identification of manual scavengers and insanitary latrines;
5. Prohibition of hazardous manual cleaning of septic tanks and sewers, so as to ensure that health and safety of such workers is not compromised;
6. More stringent penal provisions for contravention of the Act; and
7. Vigilance and monitoring Committees at the Sub-division, District, State and Central levels.

#### Effects of Manual Scavenging:

1. Normally low socio-economic strata of society are engaged in manual scavenging. This creates discrimination among the people and the scavengers suffer from an extreme form of social exclusion.
2. Scavengers suffer not only from constant but sometimes debilitating diseases (such as eye infections, diarrhoea, and asthma)
3. The scavenging work itself, in combination with the physical(health)and psychological impact it has on those who perform it, plays a part in maintaining caste discrimination as it reaffirms the traditional justification for the exclusion of members of this caste, that is, they are a "polluted" dirty people.



**Figure 68 B:** Woman engaging in manual scavenging

#### Plumbers should do the following regarding manual scavenging:

- Educate the owners of the household about the need to eliminate manual scavenging
- Ensure that the septic tank or its connection does not provide options for manual scavenging.
- The Sewerage services shall be humanized and made free from all forms of hazard and squalor.
- Ensure that the cleaning of sewers and septic tanks has to be done using mechanical devices.
- The sanitation workers shall be provided adequate protective devices and welfare measures.

### SECTION 4: Occupational health and safety during plumbing

#### Tips to maintain and work with manholes (As per Ref: IS 11972 : 1987 - Reaffirmed in 2002)

##### Maintenance:

1. Manhole cover should be water tight.
2. Avoid infiltration of water through cracks and joints
3. Cracks should be attended immediately.

4. Manholes should be closed immediately after the completion of inspection.
5. Damaged covers should be replaced immediately.

#### Precautions to be taken while entering a manhole / sewer line / septic tank:

##### A. Against gas hazards:

1. Use only safety gas proof electric lighting equipment or mirror for reflection of light. Workman may enter with safety belt attached with at least two men available at the top.
2. The ladder step or rung should be examined before putting full weight on it.
3. Portable air blowers are recommended for ventilation.

##### B. Against infection:

1. Cuts and grazes should be covered with water proof plasters.
2. Effective immunization of workers against diseases such as typhoid, cholera, tetanus etc should be done by vaccination.
3. Rubber gloves and gumboots should be used without fail.
4. Keep fingers out of nose, mouth and eyes to avoid infection.
5. When work is completed, thoroughly wash all contaminated parts of the body.



**Figure 69:** A sewerage worker clears a choked drain

##### C. Safety:

1. Use safety helmet with cap lamp
2. Use eye protectors
3. Use gas mask and breathing apparatus.
4. First aid equipment should be available.

##### D. Procedure:

1. Collect and check all safety equipment.
2. Set up adequate road markings.
3. For ventilating the system, open up
  - The working manhole
  - Next manhole upstream and
  - Next manhole downstream.

##### E. After completion of work:

1. Replace all grids, guard rails and manhole covers.
2. Wash thoroughly before eating anything.

## ***Notes***

# Appendix

## **Chapter Objective:**

- The Appendix provides more information to supplement / complement the concepts described in the chapter 1 to chapter 4.
- Chapter 1 – Pipes and fittings used in plumbing
- Chapter 2 – Testing of sanitary pipes and sewer

Appendix

## Chapter 1: Pipes and Fittings Used in Plumbing

**Pipes and Fittings used in Plumbing works:** Any plumbing system involves use of pipes for either water supply or for drainage system.

**Joints** and all parts of **plumbing system** must be both **gas-tight and water tight**. Improper joints on water piping will result in leaks, which can cause a great waste of water and improper joints on drainage piping will result in leaks, which can cause a great health hazard.

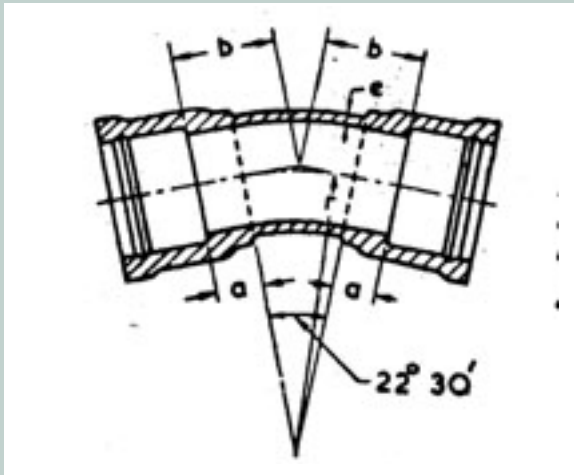
Type of Pipe		Location/where normally used
Cast Iron		Water supply mains, distribution and conveyance of sewage. Pipes: IS 1536 : 2001. CI Fittings: IS 1538 :1993 - Reaffirmed in 1999.
DI pipes		Water supply mains, distribution and conveyance of sewage. Pipes: IS 8329 : 2004 - Reaffirmed in 2005. DI Fittings: IS 9523 : 2000 - Reaffirmed in 2005
Steel		MS (GI pipes) – Water supply distribution (generally smaller diameter pipes) Pipes & Fittings: IS 1239 (Part 1) : 2004 & IS 1239 (Part 2) : 2011. Water supply mains (generally larger diameter pipes) Pipes: IS 3589:2001.
Concrete		Conveyance of water and sewage. Pipes: IS 458 : 2003. CI Fittings: Fabricated.
Stoneware		Conveyance sewage. Pipes: IS 651 : 2007.
Plastic – UPVC		Potable water supply (UG) :IS 4985 : 2000 - Reaffirmed in 2005 Soil and Waste Discharge System Inside Buildings including Rain Water System : IS 13592:1992 - Reaffirmed in 2002 Type A – Ventilation & Rain water Type B – Soil & Waste UG Sewerage & Drainage System IS 15328 : 2003 CPVC - Internal Water Supply inside the Buildings

Type of Pipe		Location/where normally used
<b>Asbestos cement</b>		Conveyance water and sewage. Pipes: IS 1592 : 2003. Fittings: IS 1624 (Part 2) : 1994.
<b>LDPE</b>		For irrigation & Water supply. Pipes: IS 3076 : 1985 - Reaffirmed in 2003
<b>HDPE</b>		Potable water supply Pipes: IS 4984 : 1995 - Reaffirmed in 2002 Grades: PE - 63, PE-80 & PE- 100.

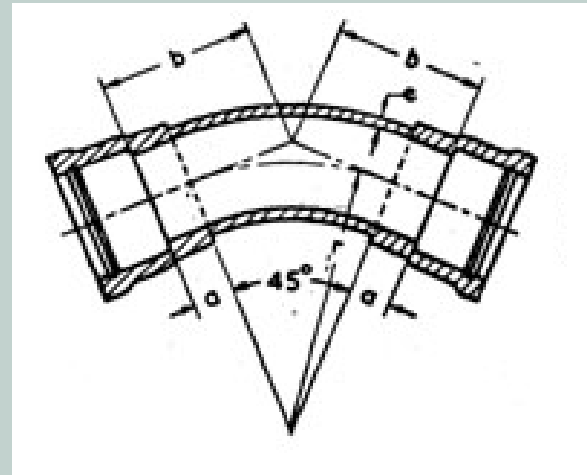
**Table 11:** Types of pipes used in water supply and drainage works

CI PIPE FITTINGS – IS 1538 : 1993 - Reaffirmed in 1999

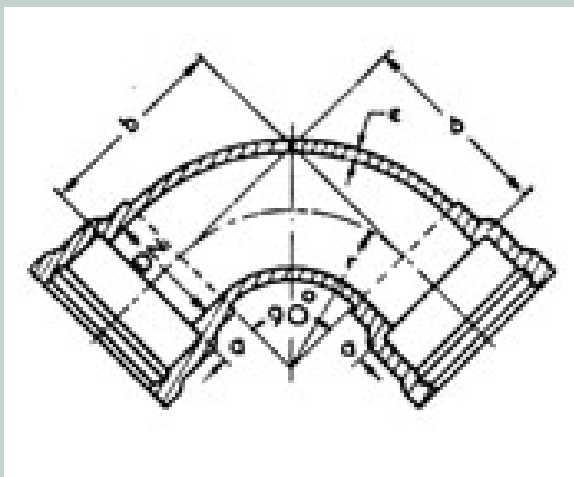
Bends 22.5°



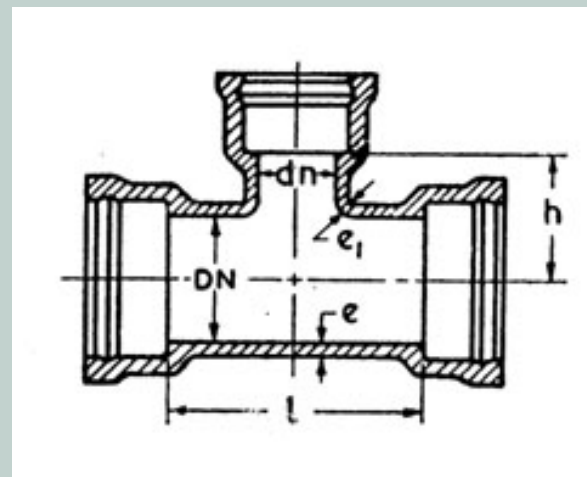
Bends - 45°



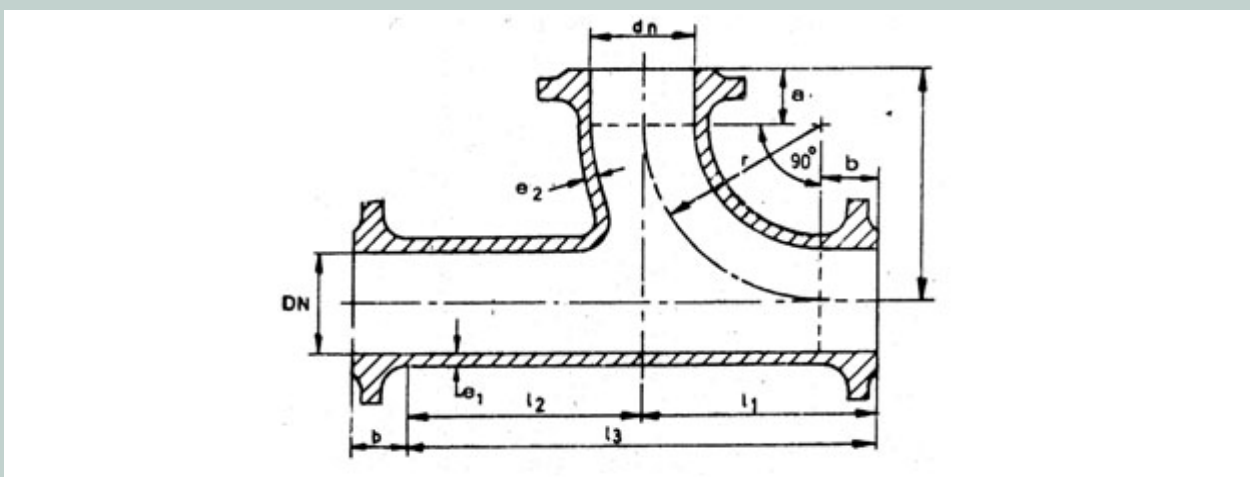
Bends - 90°



Tee Joint



Tee Junction

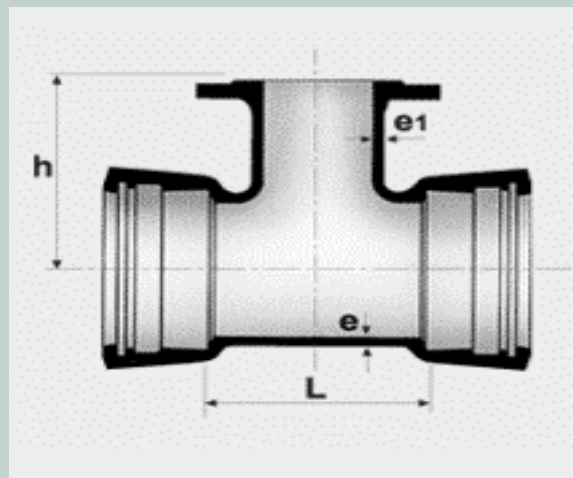
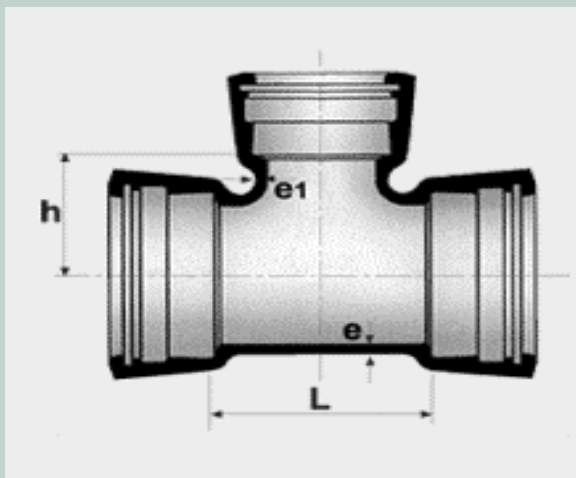




**DI Pipe Fittings – IS 9523:2000 - Reaffirmed in 2005**

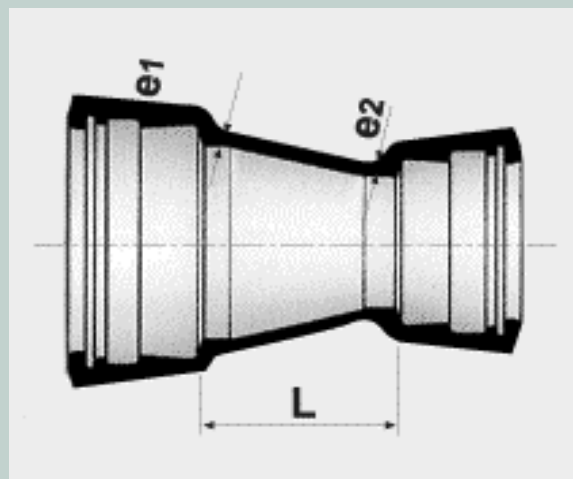
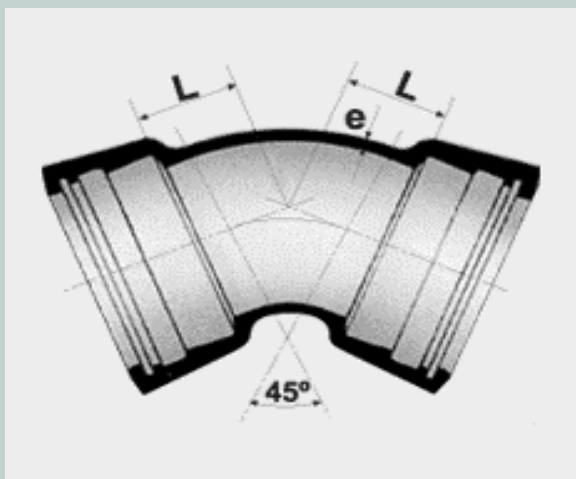
These fittings are available in sizes from 80 mm to 1600 mm

**All Sockets, Flange on Double Sockets Tees**



**Double Socket 45° Bend**

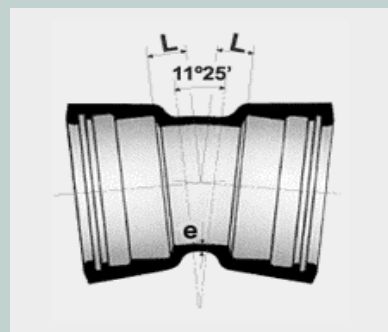
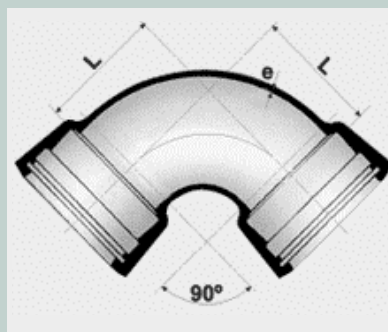
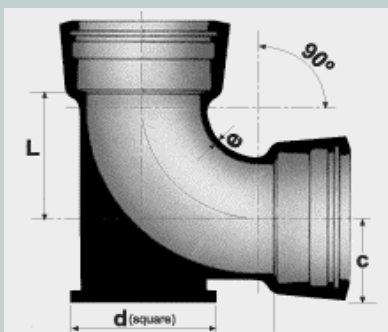
**Double Socket Concentric Taper**



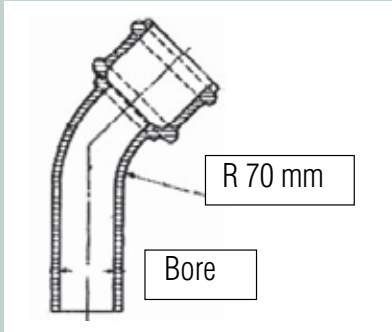
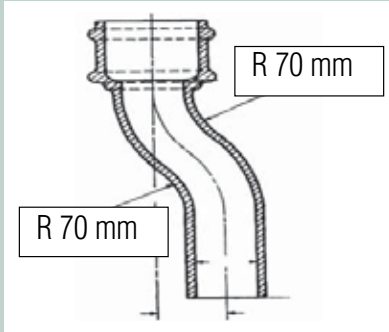
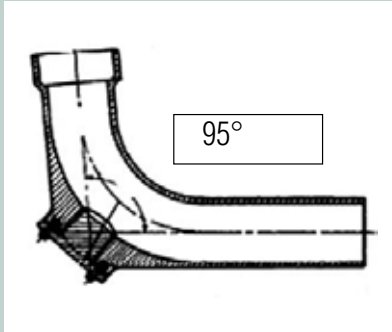
**Duck Foot Bend**

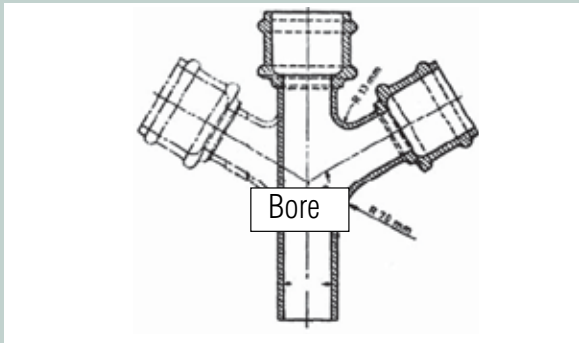
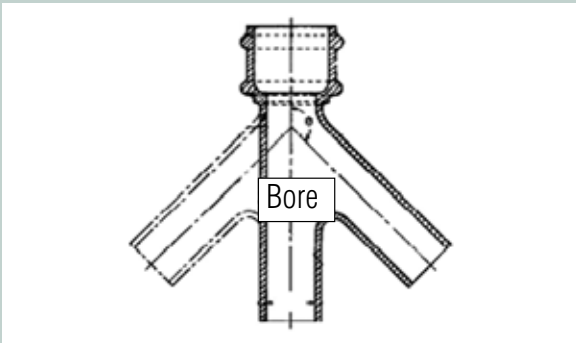
**Double Socket 90° Bend**

**D Socket 11 1/4° Bend**

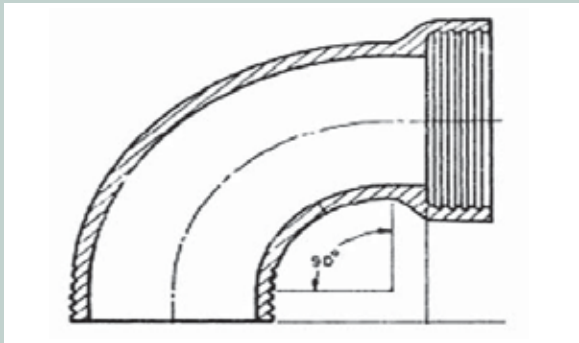
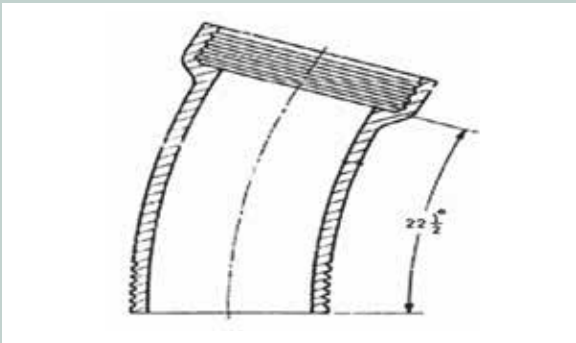
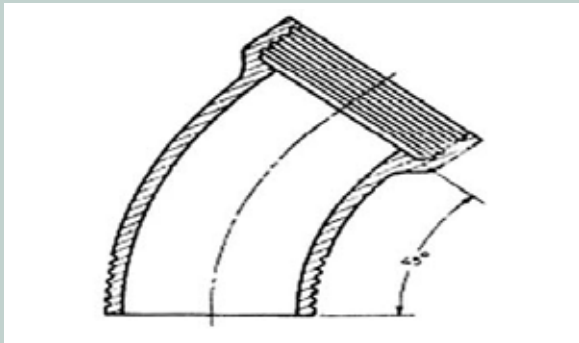
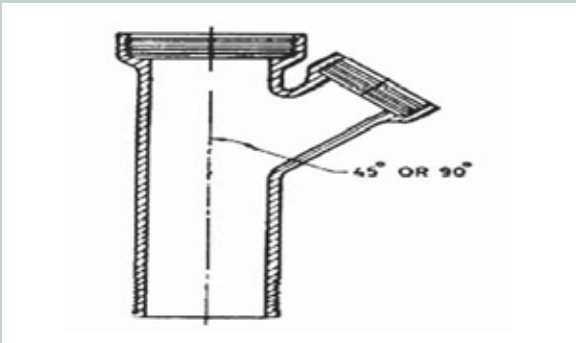


**FITTINGS AND FIXTURES OF AC PIPES - IS 1626 (Part 2) : 1994 - Reaffirmed in 2005**

Plain Bend	Swan Bend	Sanitary Bend
		

Single and Double equal joints	Single and Double equal joints with inverted junctions
	

**Fittings of Stone ware pipes - IS 651 : 2007**

Stone ware pipes	
<p data-bbox="411 1267 564 1294">One quarter Bend</p> 	<p data-bbox="1098 1267 1235 1294">One sixth Bend</p> 
<p data-bbox="411 1709 564 1736">One eighth Bend</p> 	<p data-bbox="1026 1709 1299 1736">Half section channel Junction.</p> 

## Fittings of U PVC pipes - IS 4985 : 2000 - Reaffirmed in 2005

Fittings of U PVC pipes			
<b>Cleansing Pipe</b>	<b>T</b>	<b>Single 'Tee' with Door</b>	<b>Double 'Tee'</b>
			
<b>Double Tee with Door</b>	<b>Coupler</b>	<b>Reducer</b>	<b>Single Y</b>
			
<b>Single 'Y' with Door</b>	<b>Double 'Y'</b>	<b>Double 'Y' with Door</b>	<b>Bend 87.5°</b>
			
<b>Bend 135°</b>	<b>Bend with Door</b>	<b>Rubber seal Ring</b>	<b>Lip Ring for P/Q/S Trap</b>
			
<b>P - Trap</b>	<b>Q - Trap</b>	<b>S - Trap</b>	<b>Pipe Clips</b>
			
<b>Nahani Trap</b>	<b>Vent Cowl</b>	<b>Multi floor Trap</b>	
			

The fittings are available in sizes suitable to the pipes.

**They key applications of the above mentioned fittings are detailed below.**

- **Cleansing pipe** - A fitting provided in a run of pipe with a door allowing the cleaning of pipe when required.
- **Single T** - Single T is used to connect PVC pipe line at 87.50 or 92.50. These are normally used for sewage stacks.
- **Double Tee** - Double T is used to connect two adjacent branch PVC pipe lines at 87.50 or 92.50.
- **Double Tee with door** - Double T with door is used to connect PVC pipe line at 87.50 or 92.50 but it is having screwed door for cleaning or for flushing.
- **Coupler** - For joining pipes of similar diameter couplers are used as an outer fitting.
- **Reducer** - For joining pipes of different diameters couplers are used as a junction. These are placed as an outside fixture.
- **Single Y** - Single Y is used to connect PVC pipe branch line for sewerage, at 450°.
- **Single Y with door** - Single Y is used to connect PVC pipe branch line at 450 but it is provided with screwed door for cleaning in case of any blockage occurring in the stack above. These can be either left hand type or right hand type.
- **Double Y** - Double Y is used to connect two PVC pipe branch lines at 450°.
- **Double Y with door** - Double Y with door is used to connect two PVC pipe branch lines at 450 but it is provided with screwed door for cleaning.
- **Bends** - Different bends at angles like 45°, 87.5° are used to give required bend to pipe line.
- It is also used as shoe for rain water drainage line.
- **Bend with door** - 87.5° Bend is used to give turn to pipe line but it is provided with screwed door for cleaning.
- **Rubber seal ring** - These are used for joining and sealing the pipes of Spigot and socket ends.
- **Lip ring for P, Q, S traps** - This is a gasket to make joints leak proof.
- **WC connector ring for P/Q/S trap** - The connectors join the WC pipe with the sewerage system.
- **Rubber Ring for WC connector for traps** - The rubber rings are used to make the joints with WC and sewerage leak proof.
- **P/Q/S traps** - The P/Q/S traps are designated as 125x110 or 110x110, depending upon the socket end connecting the WC outlet being 125 mm or 110 mm; however the end connecting the stacks or the branch is always 110 mm.
- **Nahani trap with jail** - This is used in bath room and is having the inlet as 110 mm and out let as 75 mm, and is designated as 110x75.
- **Vent cowl** - These are used to cover the vent pipes in sewerage system.
- **Floor trap** - These are used for receiving multi pipes.
- **Pipe clips** - The clips come as per diameter of pipe and have holes on either end to be fixed with nails or screws to the wall etc.

## Chapter 2: Testing of Sanitary Pipes and Sewer

### Testing of Sanitary pipes inside a building as prescribed by IS 5329 :1983 - Reaffirmed in 2001

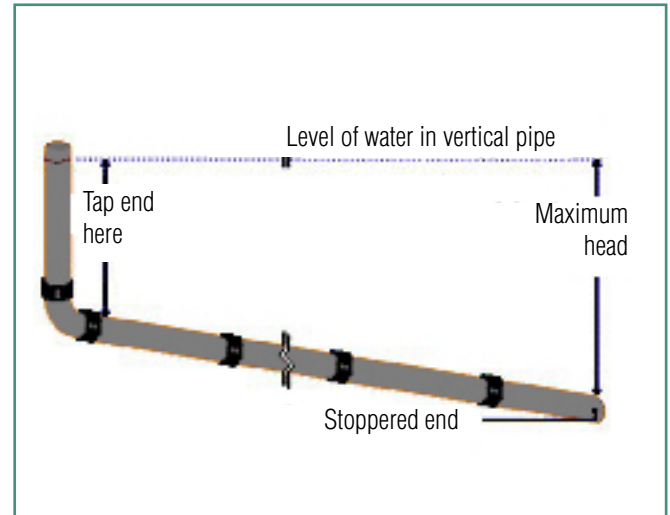
**Inspection and Testing:** The work should be inspected during installation and tested on completion. Pipe systems should be tested for gas tightness and for hydraulic performance.

The following should be ensured:

- Works according to the drawings and specification.

- Pipe brackets and clips are securely fixed with correct spacing.
- Pipe is protected by thermal insulation wherever necessary.
- Concealed pipes properly protected.
- Check for all access cover, caps or plugs.

**Water Test:** The water test may be applied before the appliances are connected and may be carried out in sections so as to limit the static head to 4.5 m. It is necessary to seal all openings affected by the test

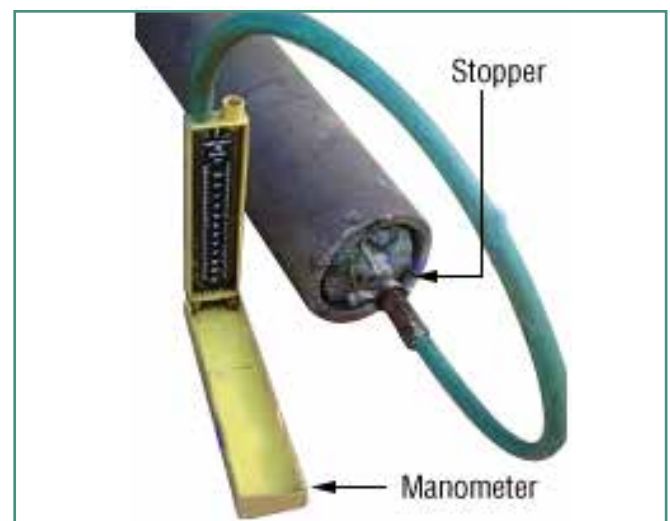


**Figure 70:** Water test

and provide support to the plugs used as stoppers.

**Air Test:** The air test may be applied by inserting expanding rubber testing plugs in the lower and upper end of the main soil pipe and main ventilating pipe and sealing the plugs with water, where possible.

- The testing plug at the upper end of the ventilating pipe should be fitted with a tee-piece with a cock on each branch one branch being connected by a flexible tube to a manometer.
- Air pressure is introduced in to the system through the other branch of the tee-piece until the desired pressure is shown on the Manometer scale. The pressure applied should be equal to 65 mm water gauge and should remain constant at for a period of 3 minutes to prove the soundness of the installation.
- Alternatively, the air pressure may be applied by passing a flexible tube form a tee-piece attached to a manometer through the water seal of the trap of the sanitary appliance, the test being



**Figure 71:** Air test

carried out as described.

### Smoke Test

Faults indicated by the air test may be located by pumping smoke in to the system with a smoke machine. Care should be taken to ensure that the system is filled with smoke before sealing with plugs.

### Hydraulic Performance

Discharge test should be made from all the appliances, singly and collectively. Obstructions from any of the pipe line should be traced and the whole system examined for proper hydraulic performance, including the retention of an adequate water seal in each trap.

### Hydraulic Testing of pipe sewers as prescribed in Central Public Health and Environmental Engineering Organization Manual

#### Water Test

Each section of sewer shall be tested for water tightness preferably between manholes.

- The sewers are tested by plugging the upper end with a provision for an air out let pipe with stop cock. The water is filled through a funnel connected at the lower end provided with a plug. After the air has been expelled through the air out let, the stop cock closed and the water level in the funnel is raised to 2.5 m above the invert at the upper end.
- Water level in the funnel is noted after 30 minutes and the quantity of water required to restore the original water level in the funnel is determined.
- The pipe line under pressure is then inspected while the funnel

is still in position.

- There shall not be any leaks in the pipe or joints (small sweating on the pipe surface is permitted).
- Any sewer or part there of that does not meet the test shall be emptied and repaired or re laid as required and tested again.
- The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 liters/mm diameter of pipes per kilometer length per day.
- For non-pressure pipes it is better to observe the leakage for a period of 24 hours if feasible.

#### Air Test

Air test becomes necessary particularly in large diameter pipes when the required quantity of water is not available for testing.

- It is done by subjecting the stretch of pipe to an air pressure of 100 mm water column by means of hand pump. If the pressure is maintained at 75 mm the joints shall be assumed to be water tight. In case the drop is more than 25 mm the leaking joints shall be traced and suitably treated to ensure water tightness.
- The exact point of leakage can be detected by applying soap solution to all the joints in the line and looking for air bubbles.

#### Other Tests

##### *Smoke test*

Smoke testing is one of the most efficient and cost effective methods of locating sources of inflow and infiltration problems with **sewers**.

**Dye testing** is a method used to locate rain or ground water entry points into the **sanitary sewer system**.

# References

References



## References

- Bureau of Indian Standards, SP 35: 1987 Handbook on Water Supply and Drainage (with Special Emphasis on Plumbing)
- Code of Practice for Installation of Septic Tanks-IS 2470 (Part 1) : 1985 - Reaffirmed in 2001
- Code of Practice for Installation of Septic Tanks-IS 2470 (Part 2) :1985 - Reaffirmed 2001
- ER. G S Bajwa, Practical Hand Book on Public Health Engineering
- IS 458 : 2003 – Precast Concrete Pipes (With and Without Reinforcement) - Specification (Fourth Revision)
- IS 1172 : 1993 - Reaffirmed in 1998 – Code of Basic Requirements for Water Supply, Drainage and Sanitation
- IS 1200 (Part 19) : 1981 - Reaffirmed in 2002 – Method of Measurement of Building and Civil Engineering Works (Third Revision) - Part 19 Water Supply, Plumbing and bains
- IS 1536 : 2001 - Centrifugally Cast (Spun) Iron Pressure Pipes for Water, Gas and Sewage Specification (Fourth Revision)
- IS 1538 : 1993 - Reaffirmed in 1999 - Cast Iron Fittings for Pressure Pipes for Water, Gas and Sewage - Specification (Third Revision)
- IS 1742 : 1983 - Reaffirmed in 2002 - Code of Practice for Building Drainage (Second Revision)
- IS 2065 : 1983 - Reaffirmed in 2001 - Code of Practice for Water Supply in Buildings (Second Revision)
- IS 3589 : 2001 - Steel Pipes For Water And Sewage - Specification (Third Revision)
- IS 4984 : 1995 - Reaffirmed in 2002 - Highdensity Polyethylene Pipes for Water Supply - Specification (Fourth Revision)
- IS 4985:2000 - Reaffirmed in 2005 - Unplasticized PVC Pipes for Potable Water Supplies — Specification (Third Revision)
- IS 5329 : 1983 - Reaffirmed in 2001 - Code of Practice for Sanitary Pipe Work Above Ground for Building (First Revision)
- IS 5611 : 1987 - Reaffirmed in 2002 - Code of Practice for Construction of Waste Stabilization Ponds (Faculative Type) (First Revision)
- IS 6295 : 1986 - Reaffirmed in 2001 - Code of Practice for Water Supply and Drainage in High Altitudes and/or Sub-Zero Temperature Regions (First Revision)
- IS 8329 : 2000 - Reaffirmed in 2005 - Centrifugally Cast (Spun) Ductile Iron Pressure Pipes for Water, Gas and Sewage - Specification (Third Revision)
- IS 9523 : 2000 - Reaffirmed in 2005 - Ductile Iron Fittings for Pressure Pipes for Water, Gas & Sewage - Specification (First Revision)
- IS 11208 : 1985 - Reaffirmed in 2007 - Guidelines for Registration of Plumbers
- IS 11972 : 1987 - Reaffirmed in 2002 - Code of Practice for Safety Precautions to be Taken When Entering a Sewerage System
- IS 12183 (Part 1) : 1987 - Reaffirmed in 2004 - Code of Practice for Plumbing in Multi-Storeyed Buildings
- IS 13592 : 1992 - Reaffirmed in 2002 - Unplasticized Polyvinyl Chloride (UPVC) Pipes For Soil and Waste Discharge System Inside Buildings Including Ventilation and Rain Water System - Specification
- IS 15328 : 2003 - Unplasticizednon-Pressurepolyvinyl Chloride ( PVC-U ) Pipes For Use in Underground Drainage and Sewerage Systems - Specification
- Manual on Sewerage and Sewage Treatment - Ministry of Urban Development - December 1993 & Final Draft May 2012
- Manual on Water Supply and Treatment -Ministry of Urban Development - May 1999
- Alternate Sewage Options for Residents - Technology Options for Urban Sanitations
- SP 7: National Building Code of India 1983 PART IX Plumbing Services
- Uniform Plumbing Code India – 2011
- Water and Environment Research Foundation – Fact Sheet C4 and CPHEEO Manual on Sewerage and sewage Treatment



# Glossary of plumbing

Glossary

**Back Flow:** The act of water traveling from one system back into any part of the main distribution system (usually by siphoning).

**Back Flow Preventer:** A device to prevent backflow i.e. into a potable water supply. Usually required for sprinkler systems, handheld showers, pullout faucet spouts, kitchen sprayers, etc.

**Back Pressure:** Pressure that resists the flow of fluid in a piping system.

**Back Siphonage:** The negative pressure that causes backflow.

**Back Vent:** Plumbing fixture's separate vent in a building drainage system.

**Back Wash:** The process of cleaning a filter by reversing the flow of water through it. Accumulated sediments are sent to waste.

**Back Siphonage:** The negative pressure that causes backflow.

**Black Water:** The discharge from water closet and urinal is called Black water.

**Biological filters:** It is a Soil Absorption Systems used to treat the effluent from the ST where the **soil is relatively impervious, water logged areas** or where limited land area is available.

**Building Drain (BD):** The building drain is the part of the lowest horizontal piping of a drainage system which receives the discharge from soil, waste and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning one meter outside the building wall.

**Building drainage system** consists of plumbing fixtures, drainage pipes & fittings and septic tanks/public sewer.

**Building Sewer:** The building sewer is the part of the horizontal piping of a drainage system which extends from the end of the building drain and which receives the discharge of building drain and convey it to a public sewer, private sewer, individual sewage disposal system or other point of disposal.

**Check Valve:** A type of backflow preventer installed in a pipe run that allows water to flow in only one direction.

**Dispersion Trench:** It is a Soil Absorption Systems used to treat the effluent from the ST.

**Drain/waste/soil pipes** are large pipes that carry waste water and other wastes away from the home and into appropriate places such as septic tanks or sewer mains.

**Filter Effluent:** The liquid discharged from a biological filter.

**Filter Media:** Materials, such as clinker, broken stone and gravel through which sewage flows and on the surface of which zoological films develop.

**Frost Line:** The line joining the points of greatest depths below ground level up to which the moisture in the soil freezes.

**Galvanizing:** The process of applying a coating of zinc to the finished product to provide corrosion protection. The coating can be applied by hot dipping or electrolytic deposition.

**Grey Water:** The discharge from bathtubs, showers, wash basins, kitchen sink, washing machine which does not contain human excreta is called Grey Water.

**Hard Water:** Natural water containing impurities in various proportions. Traditional hardness is a measure of calcium or dissolved solids in a solution, measured in parts per million. Hard water generally ranges from 100 to 250 ppm.

**High Altitudes:** Elevations higher than 1 500 m above mean sea level (MSL).

**Hydraulic Pressure:** Pressure that exists in a system containing non-compressible liquid.

**Invert Level:** The distance between the ground surface level to the base interior level of a sewer pipe.

**Lagging:** Thermal insulation on pipes.

**Leach Field:** Porous soil area, through which septic tank leach lines run, emptying the treated waste.

**Leach Lines:** Pipes that carry effluent from the septic system out to the leach field.

**Leach pit:** Leach pits/ Soak pits/ Seepage pits are used to remove contaminants and impurities from the liquid that emerges from the septic tank and safely disperses the same into the soil.

**Leakage:** Loss of fluid usually due to mechanical breakdown or gasket wear.

**Manhole:** Access opening to a hole, usually with a cover, through which a person may enter a sewer, boiler, drain, etc. (usually round to prevent the cover from falling into the opening).

**Manhole Cover:** A manhole cover is a removable plate forming the lid over the opening of a manhole, to prevent anyone or anything from falling in, and to keep out unauthorized persons and material.

**Outlet / Discharge:** The opening through which the water exits the pump.

**Outlet Sewer:** Pipe section in a septic system which runs between the septic tank and the drainage field.

**Overflow Tube:** The vertical tube inside a toilet tank that directs water into the bowl in case the ballcock malfunctions. It is usually part of the flush valve. It prevents potential water damage caused by a tank overflow. A “constant-running” condition alerts the user to a problem. On most toilets, the overflow tube also has a refill tube flowing into it, which directs water from the ballcock through the overflow tube to the bowl, after a siphon break.

### Plumber

A plumber is a person who installs and maintains piping for water and their drains and waste systems in a dwelling, business or industrial facility. He installs bathroom appliances such as showers, toilets, sinks, kitchen appliances (e.g. dishwashers), water heaters required in a new or remodelled houses or buildings.

Plumbers need various skills to perform their jobs successfully like blueprint reading, ability to locate through diagrams locations for installation of pipes, fitting pipes together for the correct functioning of plumbing systems. A plumber shall be aware of basic Plumbing Codes and Standards specified.

### Plumbing

Pipes, fixtures and other apparatus inside a building for bringing in water supply and removing the waste water out of the building constitute plumbing system. Plumbing is a skilled trade of working with the above pipes, fixtures and apparatus for use with water and drainage.

**Plumbing Fixture** A general term applied to any plumbing receptacle, device or appliance that can be temporarily or permanently fixed in place. It is connected to the drinking-water supply or to the drainage system either by an indirect or direct connection.

**Plumbing Vent Pipes** are an integral part of a plumbing system as they allow the piping to “breathe”. Air flow is necessary to equalize pressure in plumbing systems and plumbing vents allow for proper flow of air through the pipes.

**Pressure Pipes** that carry fresh water to various fixtures.

**Public Sewerage System (PSS):** The sewerage system which is taken care by local authority.

- **Combined PSS:** The Sewerage system that collects both Storm water and Building Sewer.
- **Separate PSS:** Collects only Building Sewer.

**Raw Water** Water supplied to the plant before any treatment.

**Safety Shutoff Valve:** A device on a gas appliance that shuts off the gas supply to prevent a hazardous situation. A flame safety shutoff operates when the actuating flame becomes extinguished.

**Sand Mound:** It is used for the treatment of effluent in areas where the soil has too much clay to allow the water to seep through at the proper rate, or **the water table is too close to the ground surface.**

**Sanitary Fitting:** Fitting that joins the assorted pipes in a drain, waste, and vent system, designed to allow solid material to pass through without clogging.

**Sanitary Sewer:** House drain that carries wastewater away from the house to a sewer system or septic tank.

**Scale:** A thin coating or layer, usually calcium on the bottom of a tank or interior parts that may prevent heat transfer.

**Sewer Gas:** Gases, esp. methane, which may be combustible and poisonous from the decay of organic materials in the sewer system.

**Septic Tank (ST):** A **Septic Tank** is a watertight concrete box, buried in the ground just outside the home. The septic tank acts as a small-scale sewage treatment system common in areas where no connection to main sewerage system provided by the local body. It helps in disposing of household sewage / wastewater safely.

**Septage:** Black Water which undergoes treatment in septic tank is called Septage.

**Sewage** is the water, carrying body wastes including human excreta and other house hold waste.

- a) The discharge from water closet and urinal is called **Soil** or **Black Water**.
- b) The discharge from bathtubs, showers, wash basins, kitchen sink, washing machine which does not contain human excreta is called **Waste Water / Sullage / Grey Water**.

**Sewerage system:** Sewerage system is a closed system of pipes from the waste receptacle to the final disposal point either on land or into a body of water and the flow is gravitational or free flow and not under pressure as in the case of water supply pipes.

**Simplified sewerage system:** Simplified sewerage is an off- site sanitation technology that remove all waste water from the household environment. Conceptually it is the same as conventional sewerage, but with conscious efforts made to eliminate unnecessarily conservative design features and to match design standards to the local situation.

**Siphoning:** The suction or pulling effect that takes place in the trapway of a toilet as it is filled with outgoing water and waste.

**Small Bore System:** Small bore sewer systems are designed to receive only the liquid portion of household wastewater for off-site treatment and disposal.

**Sovent Single Stack DWV System:** The Sovent System is an engineered single stack drainage system. It offers a different concept of waste and venting by slowing the velocity of liquids and solids through a series of aerator fittings and double offsets. Before entering the building drain a deaerator fitting is placed at the base of the stack to minimize solid build up and slow the drainage before entering the building drain.

**Stack:** Any vertical pipe in the system like vertical soil or vent pipe is called stack.

**Sub-Zero Temperature Regions:** Regions where temperatures fall below 0°C and freezing conditions occur.

**Sullage:** Sullage is nothing but the Grey Water.

**Tank Effluent:** The supernatant liquid discharge from a septic tank.

**Trap:** Curved section of drain line that prevents sewer odors from escaping into the atmosphere. All fixtures that have drains must have a "P" trap installed. A toilet is the only plumbing fixture with an "S" trap.

**Trap Seal:** Height of water in a toilet bowl "at rest.". It provides the water seal which prevents sewer gases from entering the home. It is measured from the top of the dam down to the inlet of the trapway. Also referred to as deep seal.

**Thawing:** The melting of ice or snow by heat.

**Up flow anaerobic filters:** It is also a Soil Absorption Systems used to treat the effluent from the ST **in areas where dense soil condition, high water table** and limited availability of open land are factors to be considered for successful disposal of effluents by secondary treatment.

**Utilidor:** Large insulated or heated conduits used for housing water piping, in some instances waste water piping. (Utilidors, however, are not at present used in India).

**Vacuum Breaker:** An anti-siphon device that prevents the backflow of contaminated water into the water supply system.




**Vent Stack:** Upper portion of the soil stack above the topmost fixture through which gases and odors escape.

**Weir:** A long notch with a horizontal edge, as in the top of a vertical plate or plank, through which water flows, used in measuring the quantity of flowing water.



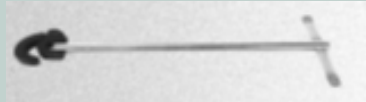


**PLUMBERS TOOL KIT:** A Plumber requires different tools to perform various operations. Some of the essential tools are detailed below.

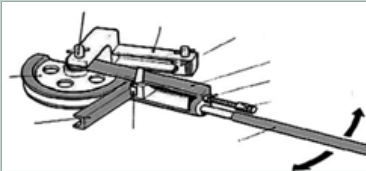



### A: Basic Tools (Easy to Carry)

Name of the Tool		Purpose of the Tool
1. Measuring Tape		<p>Measuring tape is a flexible form of ruler. It consists of a ribbon of cloth, plastic, fiber glass, or metal strip with linear-measurement markings.</p>
2. Spanners		<p>Spanners are used for fixing and opening nuts and bolts. Different types of spanners are available such as double ended spanner, ring spanners, socket spanners. Spanners are available in set of different sizes.</p>
3. Hand Hacksaw		<p>This is a fine-tooth hand saw with a blade held under tension in a frame, used for cutting materials such as metal or plastics.</p>
4. Adjustable wrench		<p>An adjustable wrench or spanner is even more likely than an open-ended spanner to wreck the head of the nut or bolt.</p>
5. Pliers		<p>Pliers should never be used to do-up or undo nuts and bolts. Use pliers on a nut or a bolt if it has already been rounded and it's impossible to use a spanner or socket.</p>
6. Torque wrench		<p>For tightening important gaskets or nuts etc where bolts require to be tightened to a torque as described in a workshop manual. It means applying a certain peak torque (as measured by a torque wrench) or by a certain angle of rotation.</p>
7. Plumbers Torch		<p>For soldering.</p>

Name of the Tool		Purpose of the Tool
<b>8. Pipe die set</b>		The pipe die set is used for threading external taper threads on pipes. The die set is available in the sizes varying between 6.35 mm to 50.8 mm.
<b>9. Taps and Tap Handle</b>		Taps are used for cutting internal threads. Normally these are available from 1.4 mm to 60 mm (1/16 to 3 inch) size.
<b>10. Plunger</b>		Used for unclogging drains. This can usually clear the blockage if it's not too far into the main drain.

**B: Secondary / Supportive Tools**

Name of the Tool		Purpose of the Tool
<b>1. Bench vice</b>		Bench vice is used for holding flat or square work piece.
<b>2. Pipe vice</b>		Pipe vice is used for holding the pipe for performing various operations.
<b>3. Basin wrench</b>		The basin wrench is useful for getting at faucet nuts in spaces not easily accessible.
<b>4. Spud wrench</b>		A spud wrench is used for working on the fittings beneath sinks, such as the nut holding the drain tailpiece in place.
<b>5. Pipe cutter</b>		Pipe cutter is used to cut the pipes.

Name of the Tool		Purpose of the Tool
<b>6. Pipe Bending Machine</b>		Pipes are cold bent to minimize the need for expensive connectors and to reduce the cost of installing pipe systems. Bending may be done by hand or machine.
<b>7. Plumbing Snake</b>		A plumbing snake is a long tool that is "snaked" into the piping of a drain or toilet in order to clear a clog .
<b>8. Drills and Drill machine</b>		A drill is a tool with a rotating drill bit used for drilling holes in various materials. All sizes of drill bits are available depending upon the size of the hole to be drilled.
<b>9. Chain Pulley Block</b>		Chain pulley blocks are used for laying big pipes. The arrangement allows lifting heavy items with less effort. Chain pulley block is fitted on the tripod.

**Table 12:** Plumbers Tool kit



***Disclaimer:***

This publication has been solely compiled as a refresher course and training module on household connectivity for plumbers. The information contained in this publication does not override any state or central government regulations and standards or manufacturer's installation requirements, all of which must be adhered to at all times.

The technical diagrams in this publication reflect the general principle behind the technology or process and may differ in appearance from the actual products. This publication is only a reference guide and readers should obtain appropriate professional advice relevant to their particular circumstances.

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## **About GIZ**

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is a federal enterprise with operations around the globe. It supports the German Government in the fields of international cooperation for sustainable development and international education. GIZ supports people and societies in shaping their own futures and improving their living conditions.

## **About GIZ -SNUSP**

In 2008 Ministry of Urban Development (MoUD) approved the National Urban Sanitation Policy (NUSP) with the aim to improve the sanitation situation in urban areas of India.

The National Urban Sanitation Policy (NUSP) based on the 74th Constitutional Amendment Act (1992), aims to strengthen Urban Local Bodies (ULBs). The overall goal of the policy is to transform urban India into sanitised, healthy and liveable cities and towns. Particular focus is given to improvement of hygienic conditions for the urban poor and women through cost-efficient technologies. The NUSP incorporates a paradigm shift and follows integrated concepts in the design and implementation of sanitation strategies. All cities and states are requested to act at par with the NUSP to develop State Sanitation Strategies (SSS) and City Sanitation Plans (CSPs) respectively. A City Sanitation Plan is a planning document that shall achieve the stepwise implementation of the goals spelt out in NUSP whereas SSS creates enabling environment for the latter.

As part of its programme 'Support to the National Urban Sanitation Policy (SNUSP)', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH supports the MoUD in the aforementioned implementation of policy guidelines at national, state and city level. The programme also supports the government to improve the management of the sanitation sector in poorer parts of the cities.

## **Approach**

The project is simultaneously working at three levels - national, state and city level. A three-tiered approach has been designed for the achievement of desired outcomes at each tier as well as constant interaction and knowledge sharing to support the "elevator effect".

### **Central level**

The program formed Technical Advisory Committee (TAC), an advisory body to the programme that recommends on specific technical issues and provide guiding directions to the stepwise implementation and improvement of water and sanitation sector with particular focus on two themes; Indian Water & Sanitation Utility 2020 and Integrated Septage Management.

SNUSP supports MoUD in evaluating the City Sanitation Plans (CSP) prepared so far and documenting the best practices and lessons learnt. This was achieved by providing guidelines and through workshops.

### **State Level**

At state level the program supported selected states in improving/preparing their State Sanitation Strategies (SSS). It provided technical inputs concerning capacity enhancement, skill development, and outsourcing of urban services such as public/community toilet complex and sewerage system.

### **City Level**

SNUSP provided handholding support at city level. The program supported preparation of city sanitation planning documents (CSP). The program supports cities in implementing the CSPs by enabling a decision process based on cost-efficient and long-term planning at city level. It supports the cities in developing bankable projects by creating sector-wise financial sustainability while strengthening service delivery.



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