

Chapter 10

HOUSEHOLD PLUMBING SYSTEM AND FIXTURES

10.1 Plumbing System

Plumbing system is the entire system of piping, fixtures, pipelines etc. for providing water supply or drainage to a building. A plumbing water supply system includes water supply and distribution pipes, storage tanks etc.

10.1.1 Entry to the home

- Houses are connected to the mains by the service pipe.
- The connection from the mains to the boundary stopcock is known as the communication pipe, and this is owned and maintained by the water supply company.
- The boundary stopcock, as the name suggests, is located just outside the boundary of the property served, with the stopcock being a control valve that turns off the water supply to the house. It is usually buried 1m below ground, at the bottom of an access chamber known as the guard pipe; which can be a short piece of any suitable pipe, the top access being protected by a small metal cover. The stopcock can be turned on or off using a long-handled key, the exact nature of which depends on the type of handle on the stopcock itself. It is switched off by turning the key in a clockwise direction.
- The service pipe, which is now known as the supply pipe, carries the water to the house. It rises slightly to ensure that all air bubbles escape. From the boundary stopcock onwards all the pipework and the appliances are the householder's responsibility. The supply pipe must be at least 750mm below the ground at all times to protect it from weathering effect. It usually enters the house at the kitchen and rises up from the floor underneath the kitchen sink.
- Water meter is fitted into the service pipe.
- The pipe (the rising main) continues directly upwards either to the coldwater tank (often referred to as the cold-water cistern because it is operated by a ballcock valve), or to feed the other cold-water draw-off points around the house.
- There should be an indoor stopcock positioned where the pipe enters the house and before the connection from the rising main to the sink to be able to cut off the supply to the house.
- The kitchen tap should always be connected directly to the rising main. If the supply pipe enters the house at another point, for example through a cloakroom or garage, then the stopcock will be fitted there. To close a

stopcock it should be turned clockwise. In some houses, generally newer ones, there may be a drain cock positioned just above the house stopcock to allow the rising main to be drained if necessary (Figure 10.1).

10.1.2 Storage tank

A storage tank is a tank for storage of water and which is connected to the main by means of a supply pipe. The following considerations are important for storage tank (Figure 10.2)

- The tank-cover should be close fitting, mosquito proof cover.
- Equilibrium ball valve with float, provide near inlet to the tank controls the inflow of water.
- Overflow pipe is provided 2.5 cm above full supply level (F.S.L) to allow water outlet incase of failure of ball valve to function properly.
- Outlet pipe is provided at the end opposite the inlet to avoid water stagnation.
- Drain pipe enables the tank to be periodically cleaned out. For this purpose, the bed of the tank is kept sloping towards the pipe.
- It should have an earth cover of at least 60 cm. when laid above the ground, the distance between the wall and pipe should be 2.5 cm.
- For multi-storied buildings, when it is necessary to pump water, separate storage tanks may be used for providing necessary suction-lift.

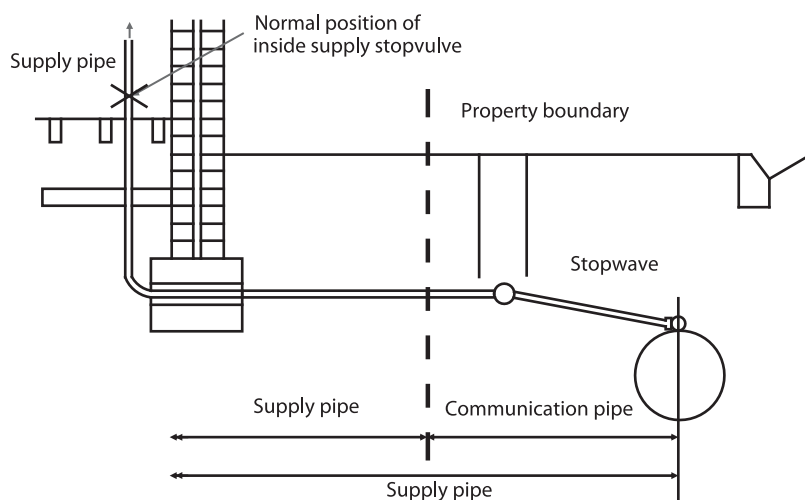


Figure 10.1: Location of service pipe, boundary stop valve and supply pipe

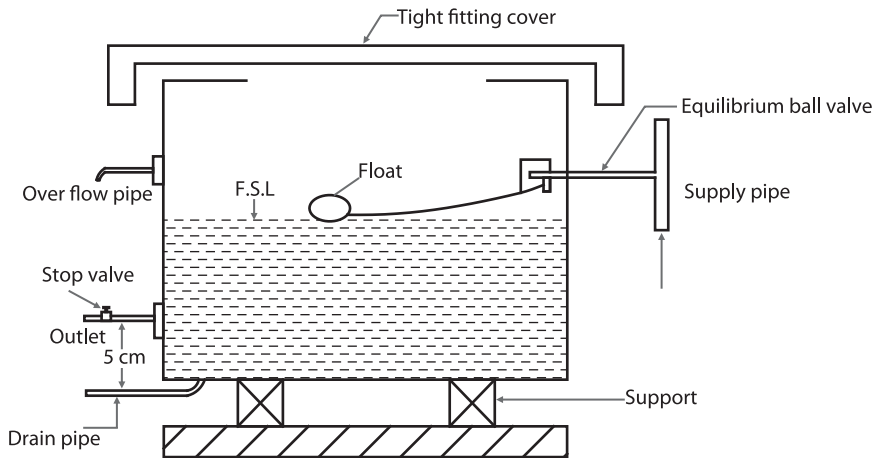


Figure 10.2: Storage tank

10.1.3 Category of the plumbing system

The layout of the water system in the house depends on a number of factors including whether there is non-electrical central heating. Essentially houses have either a high-pressure direct system, or a low-pressure indirect system that requires a cold-water storage cistern in the attic or in another elevated position.

- High-pressure direct water systems are common in the USA, Canada and most of Europe (Cheng-Li 2001). The water comes into the building and directly feeds all the cold taps and any appliances that also use cold water. This includes the WC (lavatory), hot-water storage cylinder and even the washing-machine and dishwasher. These systems are much simpler and cheaper to install than the indirect system and avoid having lots of pipework and a storage cistern for the cold water in the attic, or occasionally in the airing cupboard (Dion-Fortier, Rodriguez et al. 2009).
- The vast majority of houses in the UK and Ireland have indirect or low-pressure systems (Lee 2001), with only the cold water tap that serves the kitchen, and possibly the cold-water tap to the washing machine, directly connected to the rising main (Figure 10.3). The rising main goes up into the attic to discharge into a cold-water storage cistern. From this cistern distribution pipes feed all the other cold taps, the lavatory cistern and the hot-water system. Most water supply companies insist on the use of a storage cistern to ensure that at times of peak usage all demands are

satisfied, which would not be the case if everyone had direct systems. This is why on occasions the water tank may start to fill even though water has not been used recently. This is because, due to peak demand, the pressure has been too low to refill the tank. A major advantage of having a low-pressure system is that there is less noise, especially from lavatory systems. Burst pipes can be awful, but under mains pressure they can be extremely serious (Robert D 2009). Also, when the water supply is cut off for some reason, for example, during maintenance or repair work, a household with an indirect system still has plenty of water stored in the attic for essential use.

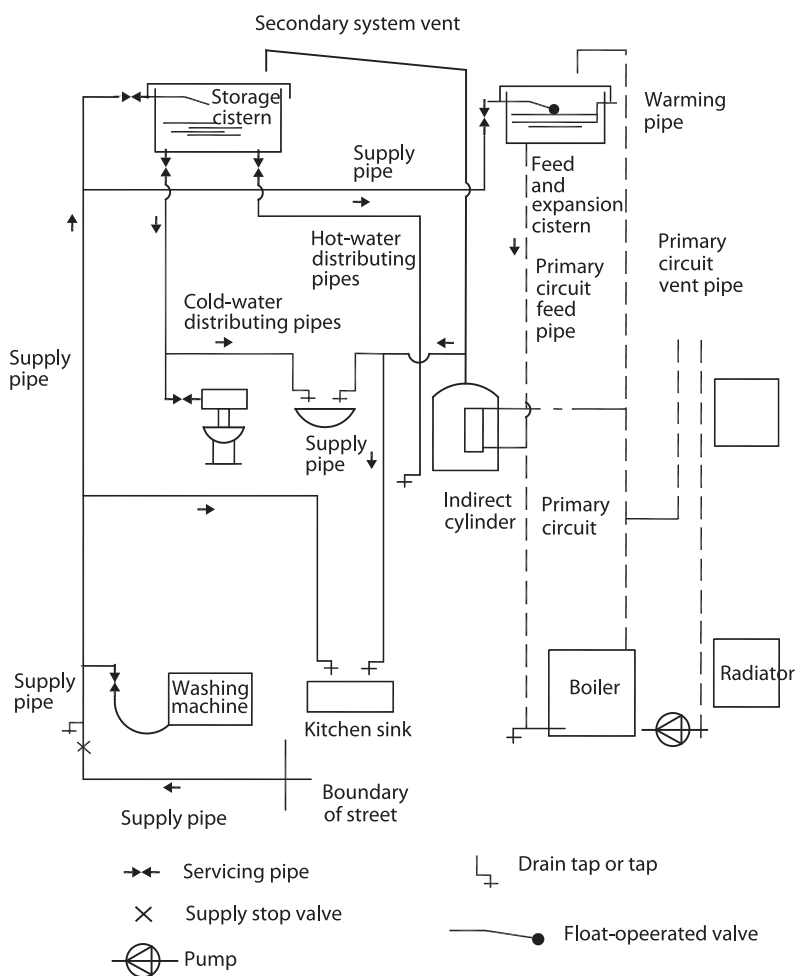


Figure 10.3: Schematic diagram of typical household plumbing system.

10.2 Principles of Designing Household Water Supply Connection

There should be absolutely no risk involved in the contaminating of water supply for domestic purposes. To ensure these following steps should be taken:

- There should not be any connection between a pipe containing potable water and pipe containing polluted water.
- There should be no back flow from any appliance towards the source of supply.
- The water supply pipe and the drainage pipes should not be laid very close to each other.
- Pipes and fittings should be thoroughly water tight in order to protect building against possible damage due to leakage and to reduce contamination risk.
- Pipe work should be protected against damage. For service pipe, lay underground.

10.3 Hot Water Connection System

Water is heated either directly or indirectly depending whether it comes into contact with a heater.

- With direct heaters the water is heated within the hotwater cylinder by one or more immersion heater elements and the hot water is then supplied to the hot taps. If a boiler is used the water is heated by circulation through the boiler and the heat is transferred to the water in the hot-water cylinder and stored there. An immersion heater is often used in the cylinder as well. Neither of these systems can supply central heating radiators.

According to type of source of fuel for heating, these water heaters are classified as:

- Gas-fired heater.
- Oil-fired heater.
- Electric water heater.

Gas-fired heater

Gas fired heaters (Figure 10.4) use natural gas, manufactured gas or propane gas fuel source. Malfunctioning and accident may occur for the following reasons:

- Lack of adequate air for combustion.
- Improper installation.
- Inadequate size.

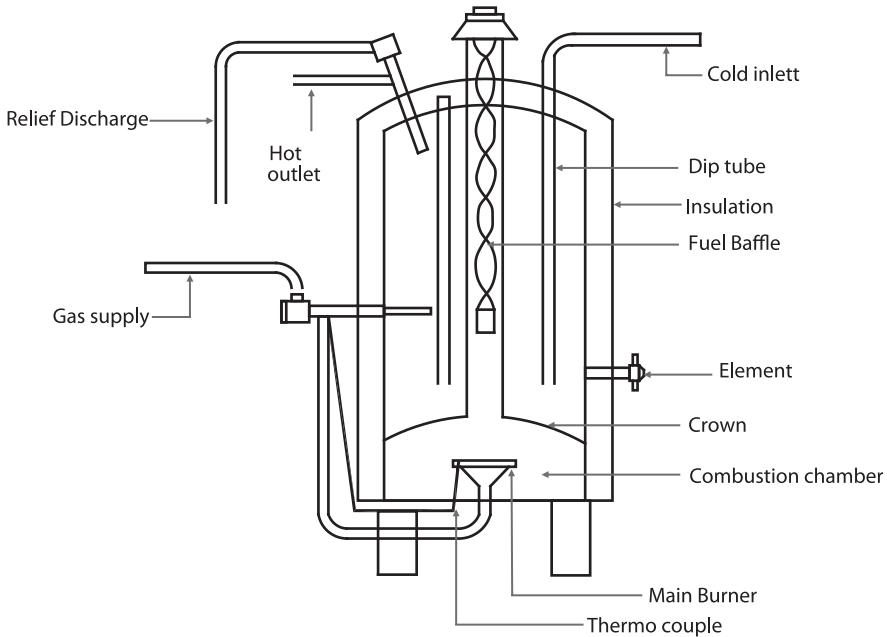


Figure 10.4: Gas fired heater

Oil-fired heater

Fuel oils are generally used. Oil fired heaters requires cleaning and soot removing frequently otherwise its efficiency will be reduced.

Electric Water Heater

Electric elements are used to heat water (Figure 10.5). It has the following advantages:

- It does not require chimneys.
- It does not require air supply.
- No soot is generated.
- Possibility of fuel leakage is eliminated.

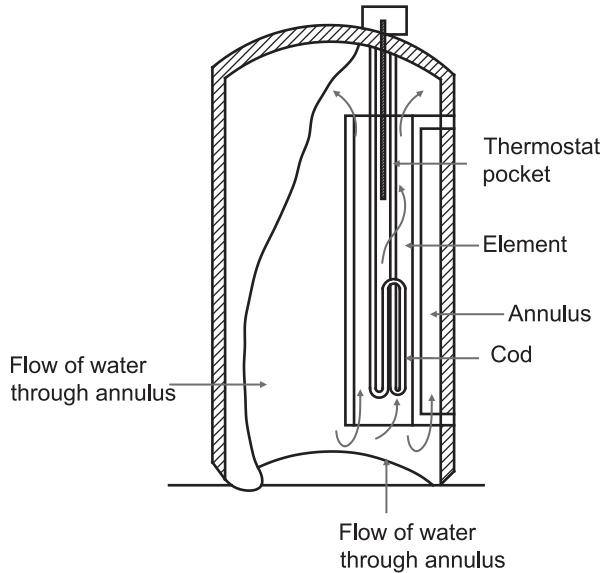


Figure 10.5: Electric heater

- Indirect heating is usually combined with the central heating system. The water in the cylinders is heated indirectly by a separate water circuit that goes through the boiler, whereas a separate hot-water circuit supplies the radiators. The central heating system is fed by a separate water circuit, supplied by a small feed and expansion cistern that is also supplied by the rising main via a small ball-valve (Figure 10.6). It is also located in the attic and is needed only to top up the system due to evaporation losses. If the feed and expansion tank is being refilled by a constant drip, check that the ball-valve does not need adjusting. If there is no water in the overflow pipe then the dripping means that there is a leak somewhere in the central heating system and the water is escaping either from the enclosed pipework or a radiator.

Hot water always rises above cold water because as it heats up it becomes lighter (less dense). In the hot-water cylinder the hot water therefore collects at the top, so cold water is fed in at the base to replace any hot water drawn. When a boiler is fitted the heat exchange pipe runs from the top to the bottom of the cylinder, so that the hot water enters at the top ensuring the most efficient exchange of heat. The hot water is taken from the top of the cylinder to feed the hot-water taps around the house (Figure 10.6). A branch from the hot-water outlet pipe from the hot-water cylinder goes back up to the cold-water cistern in the attic. This

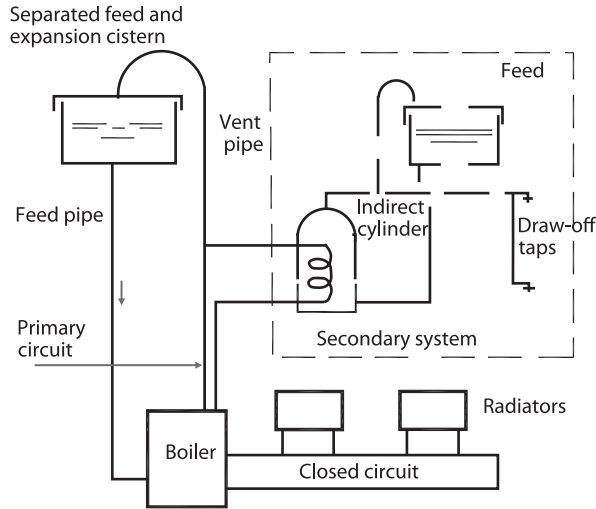


Figure 10.6: Schematic diagram of an indirect heating system.

hangs over the edge of the tank and is not immersed. It allows for expansion and for the escape of air from the cylinder. The pipe from the boiler does not discharge its hot water; it runs through the cylinder in a sealed coil. This allows heat exchange.

It is possible, if there is a drop in pressure in the mains due to a burst or perhaps due to the fire brigade using large amounts of water, that, if the plumbing has been installed incorrectly, back-suction or back-syphonage will occur. Water is syphoned back through the plumbing system to the rising main and into the water supply distribution main. For example, hose extensions are commonly fitted to cold-water taps and if the hose is immersed in water and back-syphonage occurs, all the water in the sink is sucked back into the mains until the syphon is broken. The example often quoted is the garden hose left in a bucket of weedkiller or insecticide that is drawn back up the hose and into the public supply. It is an unlikely scenario, but not impossible. If the bucket of weedkiller is replaced by a water butt containing lots of murky water, or a fishpond that is being filled, then the scenario becomes more plausible.

10.3.1 Piping layout methodologies for hot water circulation

Upfeed Circulation System: In this system, the heating unit and the storage tank are placed below the distribution lines (Figure 10.7). The distribution main runs from the top of the storage unit and feed risers are connected to the

distribution main. A hot water return is provided for each of the feed risers. The top of return risers is connected to supply riser just below the topmost supply branch. Return risers are connected to a main hot water return pipe through which the water returns to the source of supply. Air accumulated in the topmost point of each riser is drawn off when a hot water faucet is opened at a fixture.

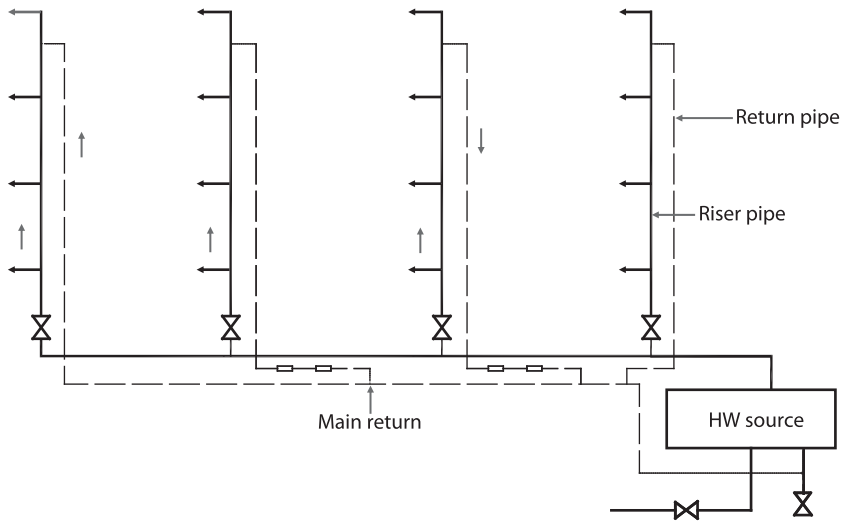


Figure 10.7: Up feed hot water circulation system

Down feed Circulation System: The main water supply pipe is extended from the source of water supply to the highest part of the building and from there water is supplied to the tap of all supply risers (Figure 10.8). Flow occurs downwards in all risers. These risers are connected to a main hot water return pipe. Air relief vent valve is used to eliminate entrapped air.

Combined Circulation System: It is a combination of upfeed and downfeed system. Some risers are used as upfeed risers and some are downfeed risers (Figure 10.9). Downfeed risers are connected to the main hot water return pipe

Inverted Down feed Circulation: Hot water source is located at the highest part of the system. Hot water is supplied to the top of all risers, a return riser is connected with the supply riser just above the lowest branch pipe to fixtures, and they are connected to a main hot water return line (Figure 10.10). An

automatic air relief valve is installed at the highest point of the system to prevent air trap..

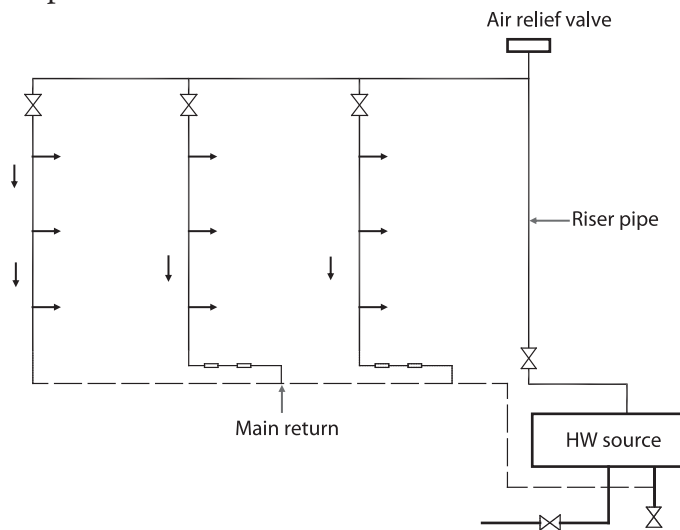


Figure 10.8: Down feed hot water circulation system

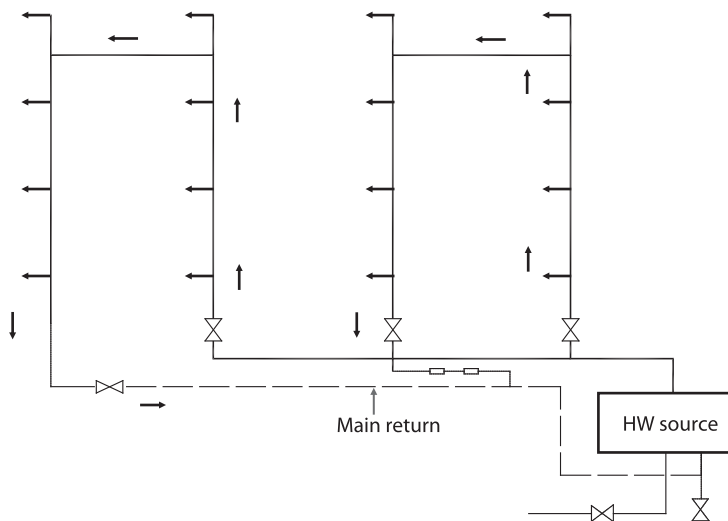


Figure 10.9: Combined circulation system

Inverted Upfeed Circulation System: In this system, a main supply pipe is extended from hot water source to the lowest part of the system with which the risers are connected. The top of risers are connected to a main hot ater

return pipe to pump back to the source with the help of a circulation pump (Figure 10.11). Automatic air relief valve is at the highest point.

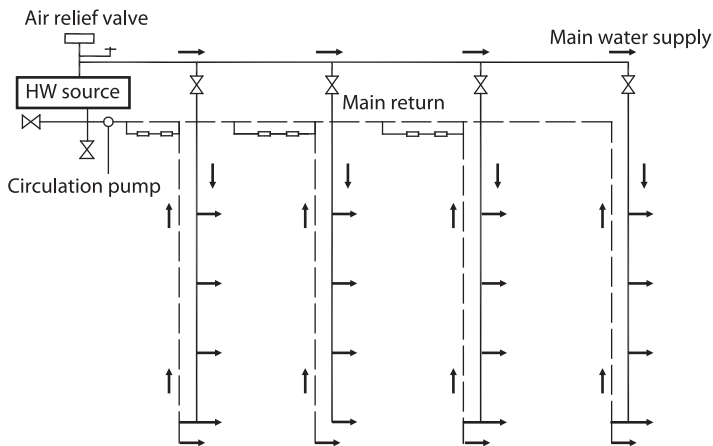


Figure 10.10: Inverted down feed circulation system

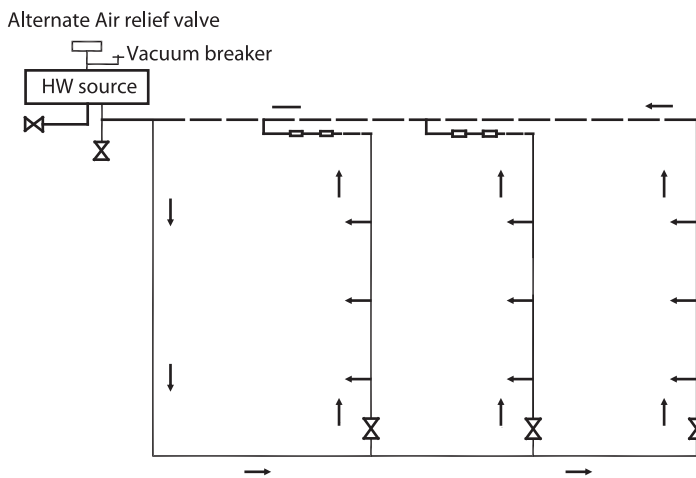


Figure 10.11: Inverted Upfeed Circulation System

Inverted Combined Circulation System: In this system, some hot water supply risers have downward flow while others have upward flow (Figure 10.12). Each upfeed riser is supplied from the bottom of a downfeed riser and the top of upfeed risers are connected to a main hot water return pipe through which water is pumped back to the hot water source. Air relief valve and vacuum breaker is installed at the highest part of the system.

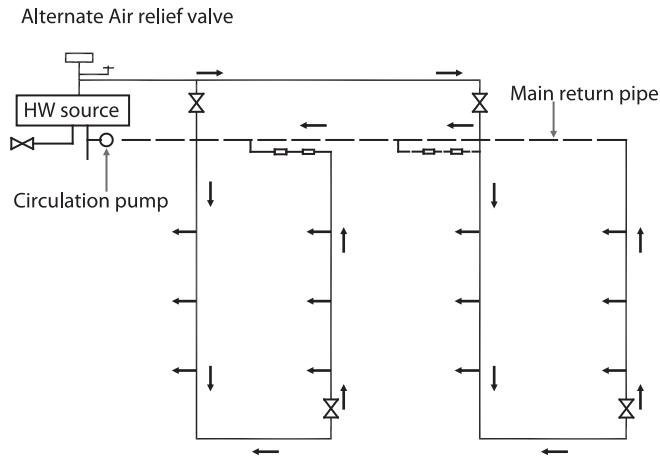


Figure 10.12: Inverted Combined Circulation System

10.4 Plumbing Fixtures

A plumbing fixture is a receptacle for wastes, which are ultimately discharged into drainage system. The fixtures most commonly included in toilet and kitchen are:

- Lavatory
- sink.
- Bathtub
- Water closet.

Lavatories: The lavatory is a basin used for washing of hands, face etc. It is usually oval-shaped. These are available in various styles, color and sizes. These are made from various materials like vitreous china, enameled pressed steel, stainless steel, plastic. These require 32mm waste pipe. The Figure 10.13 shows the various shaped and sized of lavatories.

Sink: A kitchen sink is a shallow, flat bottomed plumbing appliance used for dish cleaning. The most popular sink is single bowl, with a drain board. There are also double, triple bowl sinks with drain board in one or both sides. Bowl depth is usually 200mm. Sinks shall be provided with waste outlet at least 40mm in diameter to facilitate drainage, so that water may be retained in the bowl for normal use. The Figure 10.14 shows different types of sinks.

Bathtub: A bathtub is a receptacle for holding water and is shaped for allowing half-human body for taking bath. A standard bathtub holds about 150-180L of

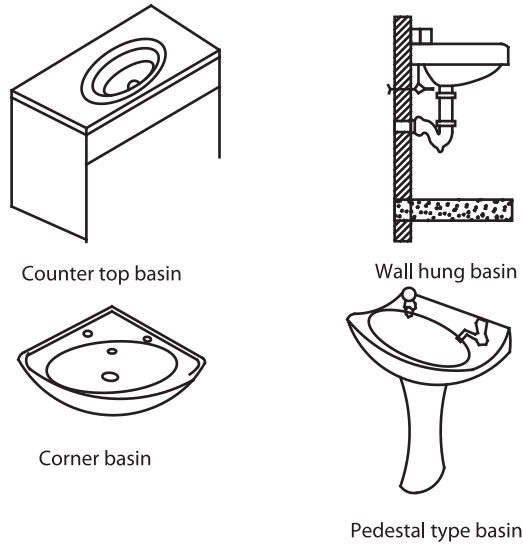


Figure 10.13: Various Lavatories

water. The length of a bathtub varies from 1500-1800 mm in length and width is 375mm. The top of bathtub is 375mm above the floor level. The Figure 10.15 shows the typical bathtub.

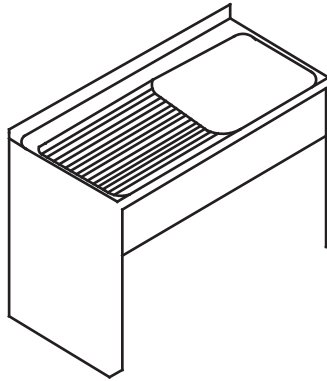
Water Closet: Water closets are water flush plumbing fixtures that receive human excrement and finally dispose off into drainage system using water as a conveyance medium. Water closets have traps as an integral part of it. According to the shape of traps these water closets are termed as S-type, P-type or Q-type water closets (Figure 10.16). S-Type water closets have its outlets towards the floor. P-type traps have their outlets towards the back wall.

On the basis of support, water closets are grouped in two categories (Figure 10.17):

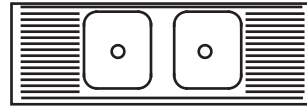
- Floor mounted
- Wall mounted

10.4.1 Operating principle of water closet bowl

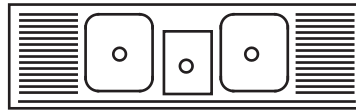
The performance of a water closet is judged by the flushing efficiency with which it disposed off the wastes received. Flushing efficiency depends upon the way of flushing action. The common types of actions are:



(a) Single bowl sink

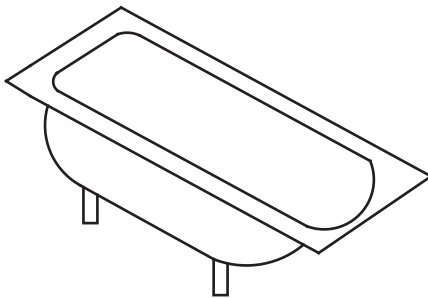


(b) Double bowl sink

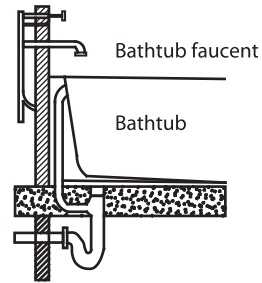


(c) Triple bowl sink

Figure 10.14: Various sinks

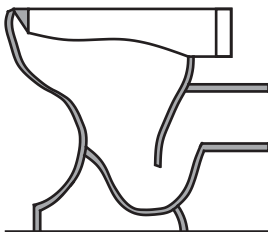


(a) Isometric view of bathtub

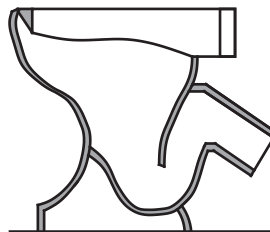


(b) Faucet and drainage piping of bathtub

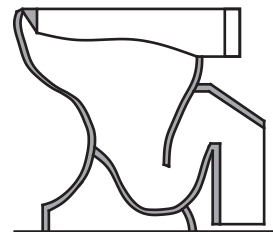
Figure 10.15: Typical bathtub



(a) P Type WC



(b) Q Type WC



(c) S Type WC

Figure 10.16: Different types of water closets

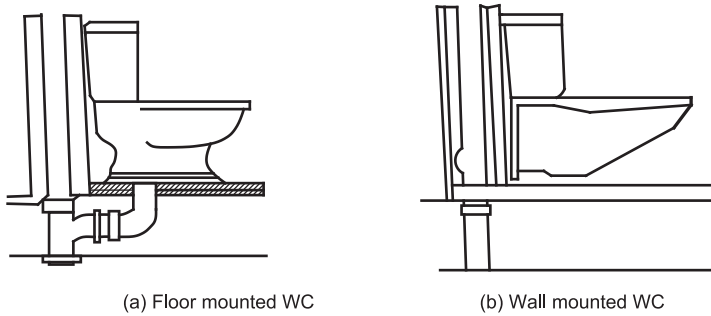


Figure 10.17: Floor and wall mounted water closets

- siphon jet
- reverse trap
- wash down
- blow out etc.

All bowls have a flushing rim around the top; flushing water is sprayed into the bowl through this flushing rim. They are described below:

- **Siphon jet:** The flushing action in the siphon-jet bowl shown in Figure 10.18 is accomplished by water in the upper leg of the trap-way by directing water jet from the jet hole at to bottom of bowl. As the water flows full in the down let of the trap-way, it eliminates the air in the passageway, thus producing a partial vacuum. Atmospheric pressure acting on water in the bowl pushes the content through the trap-way due to siphoned action. In this way the flushing action is more efficient, quick and relatively quiet.
- **Reverse Trap:** The flushing action of the reverse trap water closet bowl is similar to that of siphon jet water closets. However the water area in the

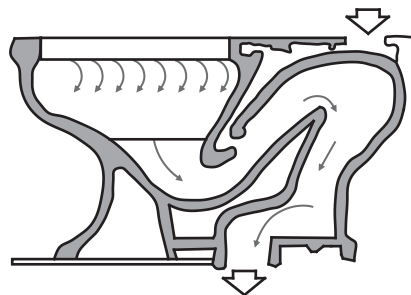


Figure 10.18: Siphon jet action of water closet

bowl and trap-way is smaller and the seal is less than that in a siphon jet closet. So less water is required for the flushing operation than a siphon jet water closet. This type of flushing is moderately noisy. This type of water closet has been illustrated in the Figure 10.19.

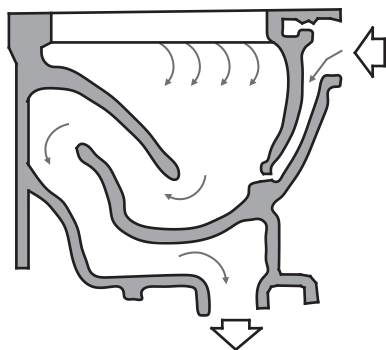


Figure 10.19: Reverse trap water closet

- **Siphon Vortex:** The flushing action in this type of water closet bowl is started by a whirlpool action followed by a flush down of the liquid containing the wastes. Water is directed through a rim to create a vortex in the water contained in the closet as shown in Figure 10.20. Though it is more expensive but it is very efficient, quiet and extremely sanitary. It has a large amount of standing water almost covering the interior surface of the bowl.

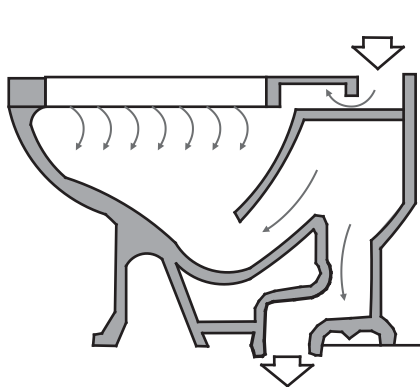


Figure 10.20: Siphon vortex water closet

- Wash down water closet:** In this type of water closet, the trap passageway is at the front rather than at the rear of the bowl (Dion-Fortier, Rodriguez et al. 2009). The flushing action of the wash down water closet bowl is created by water from the flushing rim and the jets fill the bowl until enough head is formed for flushing. The jets direct a portion of the flushing water directly over the dam of the passageway to accelerate the flushing action. Although it is less expensive, it is least efficient and noisiest of the type of water closet. It has small amount of standing water and a large exposed surface in the inside, which is susceptible of fouling, staining and contamination. Figure 10.21 illustrates a wash down water closet.

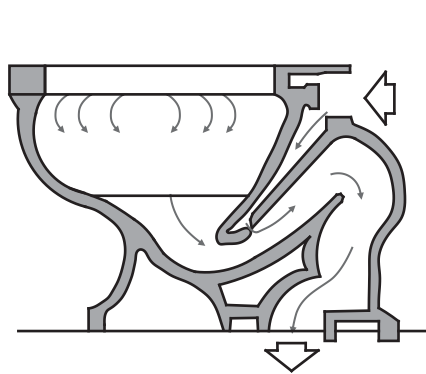


Figure 10.21: Wash down water close

- Blow-Out water Closet:** In blowout water closet flushing action is done by driving a large jet of water into the inlet of the trap passageway instead of driving by siphoned action (Figure 10.22). It is economical in the use of water, more efficient but noisy. It has a large water surface in the bowl that fouling space. This type of water closet is suitable for use in public places, schools office etc.

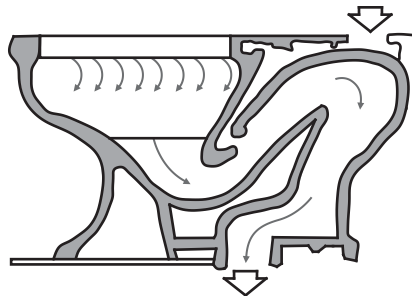


Figure 10.22: Blow-out water closet

10.5 Drainage System of Building

In order to maintain proper drainage from a building, the following requirements are to be considered.

- Drainage pipes should be adequately sized.
- Pipe run should be kept as short as possible.
- Bends and junctions should be smooth.
- At bends, junctions' access doors should be provided.
- Selected pipes should be strong enough to withstand internal and external pressure.
- All fixtures should be provided with water seal trap.

10.5.1 Categories of drainage system

Drainage system of a building can be divided into three groups:

- a. Drainage above ground
- b. Basement drainage
- c. Drainage in ground

Drainage system above Ground

The drainage system above ground can be divided into following categories:

- i. Two pipe system
- ii. One pipe system
- iii. Single stack system
- iv. Partially ventilated single stack system

i. Two Pipe System: In this system, two separate pipes are installed for conveyance of wastes generated from a building (Figure 10.23). Fixtures which receive human excreta and urine are connected to soil pipe and ultimately discharged to a drainage pipe (vertical pipe) called soil stack. Stacks are connected to sanitary sewer. Fixture, which receive waste water for example basins, bathtubs, showers are connected to a separate horizontal pipe called wastewater pipe, which discharges into a separate vertical stack known as waste water stack. These stacks are connected to a combined sewer. The soil pipes as well as waste pipes are separately ventilated, by providing, separate vent pipe or anti-siphon age pipe. This system has four vertical pipes.

Two pipes system can be used where there is no public sewer system.

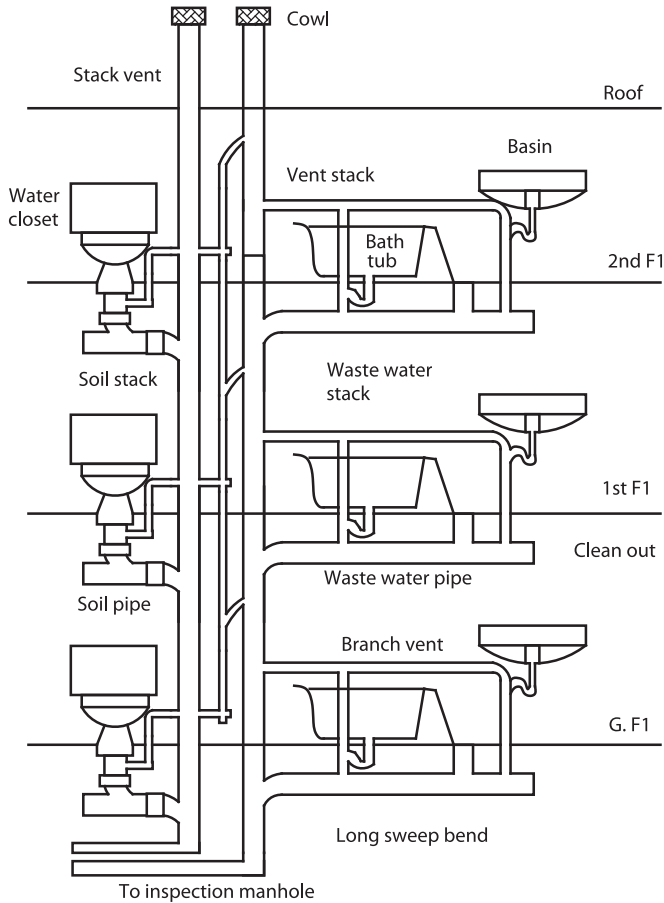


Figure 10.23: Two pipe system

- Advantages of two-pipe system:
 - Avoids danger of sewage backflow in wastewater fixtures.
 - Enables use of separated wastewater for irrigation, gardening.
 - Reduce load for septic tank where there is no public sewer.
- Disadvantages of two-pipe system:
 - Requires more pipes, so it is not economical.
 - Requires more space for piping.
 - Installation of more pipes needs more joints, so leakage possibility through joints increases.

ii. One Pipe System: In one pipe system, both soil and waste fitting are discharged into a common stack (Figure 10.24). This system should not be

developed where wastes should be discharged into septic tank in absence of public sewer system. The main pipe is ventilated at the top, in addition, a separate vent pipe is also provided. This system has two vertical pipes.

iii. Single Stack System: This system is having a single pipe for soil, waste and vent without any separate ventilation pipe. It uses only one pipe, which carries soil as well as wastewater and the same pipe is usually extended up to 2 m above roof level with a cowl to act as vent pipe for removal of gases.

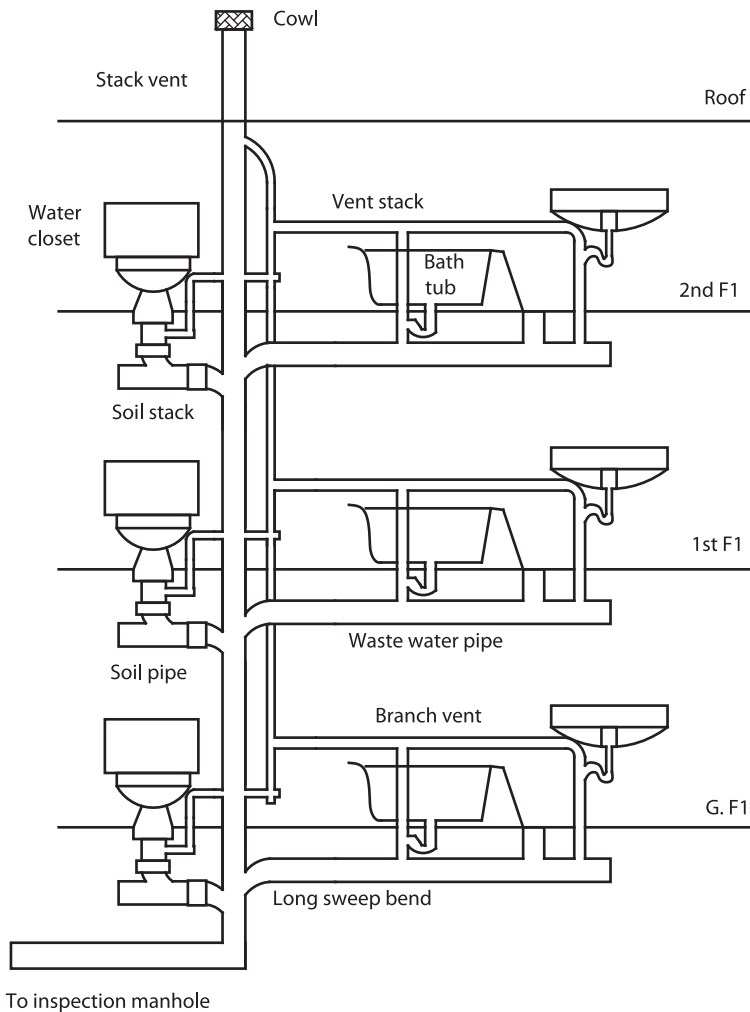


Figure 10.24: One pipe system

iv. Partially Ventilated Single Stack System: This is an improved form of single stack system, where the traps of the water closets are ventilated, by a separate vent pipe, called relief vent pipe. This system uses two pipes as in single pipe system. The single soil and waste pipe is connected to vent pipe and thus cost is reduced.

Basement Drainage System

Basement floors of a building, which is below ground level, may receive wastes from various sources like other floors above the ground. Wastewater from car wash, leaking water from various machinery and pipes running through a basement floor needs appropriate system for drainage. The basement level remains below the bottom level of public sewer. So, drainage from basement needs pumping. In case of very large basement floor, to minimize area and sloping surface considerable number of sump pits is provided at suitable locations at the bottom most basement floor. From these sump pits, wastewater is drained towards master sumps by interconnecting drainage pipes (Figure 10.25). A master sump pit is provided with an automatic sump pump, which starts pumping when the pit fills up to a predetermined level. The discharge of the sump pump is connected with building drain.

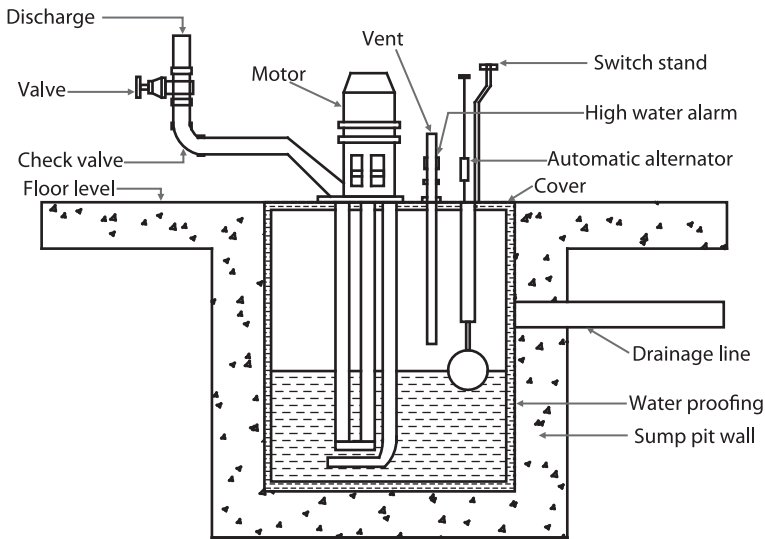


Figure 10.25: Sump pump on sump pit

Drainage in ground

Building drainage system in the ground is the portion of the plumbing system, which receives discharge of all soil and wastewater stacks within the building and conveys these to the building sewer. So it is known as collection pipe. When the stacks are installed in various locations, it may be necessary to connect some of the stacks to a drainage pipe to convey all the discharges of stacks.

It can be classified into following categories:

- **Sanitary drain:** It receives soil and wastewater discharges of a building.
- **Combined drain:** Receives sanitary waste and storm waste.
- **Storm drain:** Receives storm discharge, clear water or surface wastewater except sanitary wastes.

BOX 10.1

Plumbing situation in Bangladesh; adapted from Haq (2011)

Situation of plumbing in Bangladesh:

In Bangladesh the plumbing situation is not satisfactory and at a glance it can be said that:

- Before eighties the quality of plumbing practices was comparatively good.
- During mid eighties to mid nineties bad situation prevailed.
- After mid nineties again sign of improvement has been marked in some aspects of plumbing practices.
- Present plumbing practices are not up to the mark in comparison to other building services.

Identified major problems in plumbing:

The major problems identified in the plumbing system of Bangladesh are:

- There is no institution to produce plumbing professional.
- There is no institution to give license to the plumbing contractors.
- Very few vocational training institutions produce Plumbers.
- No record of controlling quality of plumbing items.
- No authority for monitoring execution of plumbing code.
- No exclusive and comprehensive plumbing code for practice.

- Few books on plumbing are available in the market.
- Non availability of special and occasionally used plumbing items.
- Few professionals are practicing exclusively in this field.
- Plumbing professionals are poorly valued.
- Lack of awareness and motivation regarding importance of plumbing

Identified building waste disposal related problems:

- Absence of local code of practice: there is no guideline whether one pipe or two pipe system shall be developed in buildings at particular areas subject to availability of public sewer.

Cause:

- Lack of awareness of the service providing authorities.
- Absence of good governance in the concern service provider's administration.

Cause:

- Lack of adequate documented information about the available fixtures, pipes and fittings.
- Manufacturers efforts for reducing price defying quality. Bangladesh Standard Testing Institute (BSTI) is yet to take drive for quality control of plumbing items.
- Few technical institutions have program of producing certified plumbers.
- Using substandard fixtures, pipes, fittings etc. and imperfect installation.

Cause:

- Dependence on plumbers, instead of plumbing professionals.
- Poor number of engineers practicing plumbing.
- No opportunity of becoming certified plumbing professional in the country and no system of licensing plumbing contractors.
- Unorthodox practices in drainage piping development.

Cause:

- Manufacturers, retailers and contractors quest for items of high demand, lesser price and maximum profit. They are little concern of their business ethics.
- Non availability of special, occasionally used pipes, fittings,

Cause:

- Non involvement of plumbing professionals. Not having due importance during architectural planning and design.
- Non availability of special and varieties of fixtures, pipes, fittings etc
- Non professionals planning for biased interest.
- Inefficient planning of building drainage system.

Cause:

- Lack of knowledge regarding importance of venting in plumbing. No or poor venting can endanger life, impair public health and environment.
- Avoiding venting system totally or partially.

Cause:

- Lack of proper public sewer infrastructures and its information
- Lack of sufficient space for pipe laying around the building and within the site.
- No enforcement of building regulation and local bylaws.
- To minimize the cost
- Development of improper building drain and sewer.

Cause:

- Absence of exclusive and comprehensive plumbing code.
- Few Plumbing professionals might have contributed in the preparation process of Bangladesh National Building Code (BNBC).
- Limited provisions for building drainage in the code.

Cause:

- Callousness of the service providers.
- Lack of commitment to provide good drainage and waste management services.
- Absence of proper public sewer and service system.

Cause:

- Sewer service providers are not made answerable to the stakeholders .
- Might be for reducing the load of waste for the treatment plant.
- Irrational obligatory instructions by the sewer authority

▶ **Cause:**

- Yet to anticipate the fatal consequences that may arise from the building services including plumbing system. Some fatal accidents are reported that caused due to ignorance of safety measures that would to be taken while working in some hazardous area of building waste disposal system.
- No comprehensive building regulatory system.

Cause:

- Yet to anticipate the fatal consequences that may arise from the building services including plumbing system. Some fatal accidents are reported that caused due to ignorance of safety measures that would to be taken while working in some hazardous area of building waste disposal system.

10.6 Conclusion

Plumbing is an important part of water supply system, especially for the urban areas. However, the majority of aesthetic supply problems arise from the householder's own plumbing, so installation and maintenance must be carried out by a well-experienced plumber.

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