EBCS-9

Ethiopian Building Code Standard

PLUMBING SERVICES OF BUILDINGS

Final

Ministry of Urban Development and Construction
Addis Ababa
August 2013

INTRODUCTION

To ensure public and environmental health, buildings should be provided with technically sound water supply, sanitary and drainage systems. This requires a standard code of practice that governs their planning, design, installation, use and maintenance. The code should reflect the state-of-the-art in material science, technology and approach as much as practical.

In Ethiopia, the designs and installations of building water supply, sanitary systems, and stromwater drainage have been practiced using EBCS-9 1995. EBCS-9 2013 has been prepared after having revised and updated EBCS-9 1995 that has been in use for 18 years. Various model plumbing codes were referred in the preparation of EBCS-9 2013 and include National Building Code of India, Uniform Plumbing Code, and British Plumbing Standards. Local practitioners and experts who use the code have also been consulted and relevant feedbacks incorporated.

Major improvements to the different sections of EBCS-9 1995 have been made. The section on Fire Fighting Water Supply has been removed as there is a new full-fledged code under preparation. EBCS-9 2013 has a total of eight sections with two of them being new-Administration and Solid waste management.

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SECTION 1

1 SCOPE AND DEFINITIONS

1.1 Scope

(1) This Standard lays down requirements for and given recommendations on the design, installation, testing and maintenance of plumbing fixtures, water supply for domestic and fire-fighting systems, drainage and venting and disposal systems for water-borne domestic wastes, and storm-water drainage system within premises.

(2) A list of symbols in common use has been included in this Standard.

1.2 Definition

1.2.1 General

(1) Unless otherwise expressly stated, the following words and terms shall, for the purposes of this code, have the meanings shown in this section.
(2) Words stated in the present tense include the future; words stated in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural the singular.
(3) Where terms are not defined in this code and are defined in other Codes, such terms shall have the meanings ascribed to them as in those codes.
(4) Where terms are not defined through the methods authorized by this section, such terms shall have ordinarily accepted meanings such as the context implies.

1.2.2 Terminology

Accepted Engineering Practice: That which conforms to accepted principles, tests or standards of nationally recognized technical or scientific authorities.

Access Cover: A removable plate, usually secured by bolts or screws, to permit access to a pipe or pipe fitting for the purposes of inspection, repair or cleaning.

Adapter Fitting: An approved connecting device that suitably and properly joins or adjusts pipes and fittings which do not otherwise fit together.

Air Admittance Valve: One-way valve designed to allow air to enter the plumbing drainage system when negative pressures develop in the piping system. The device shall close by gravity and seal the vent terminal at zero differential pressure (no flow conditions) and under positive internal pressures. The purpose of an air admittance valve is to provide a method of allowing air to enter the plumbing drainage system without the use of a vent extended to open air and to prevent sewer gases from escaping into a building.

Air Break (Drainage System): A piping arrangement in which a drain from a fixture, appliance or device discharges indirectly into another fixture, receptacle or interceptor at a point below the flood level rim and above the trap seal.

Access Panel: Removable panel mounted in a frame, normally secured with screws and mounted in a wall or ceiling, to provide access to concealed appurtenances or items which may require maintenance.

Air Gap: The unobstructed vertical distance through the free atmosphere between the lowest opening of a water service pipe of fixed outlet supplying water to a fixture or receptacle and the highest possible water level of such fixture or receptacle.

Air Valve: A valve that releases air from a pipeline automatically without loss of water, or introduce air into a line automatically if the internal pressure becomes less than that of the atmosphere

Alternative Engineered Design: A plumbing system that performs in accordance with the intent and provides an equivalent level of performance for the protection of public health, safety and welfare.

Appliance: A receptacle with necessary appurtenances designed for a specific purpose the use or operation of which results in a discharge into the sanitary drainage system.

Authority Having Jurisdiction: The Authority which has been created by a statute and which for the purpose of administering the Code/Part may authorize a committee or an official to act on its behalf, hereinafter called the 'Authority'.
Back Siphonage: The flowing back of used, contaminated, or polluted water from a plumbing fixture or vessel into a water supply due to a reduced pressure in such pipe (see Backflow).

Back Up: A condition where the wastewater may flow back into another fixture or compartment but not back into the potable water system.

Backflow: The flow of water or other liquids, mixtures or substances into the distributing pipes of a system of supply of potable water from any source or sources other than its intended source.

Backflow Preventer: A device or means to prevent backflow.

Base: The lowest portion or lowest point of a stack of vertical pipe.

Base Flood Elevation: A reference point, determined in accordance with the building code, based on the depth or peak elevation of flooding, including wave height, which has a 1 percent (lOO-year flood) or greater chance of occurring in any given year.

Bathroom Group: A group of fixtures consisting of a water closet, lavatory, bathtub or shower, including or excluding a bidet, an emergency floor drain or both. Such fixtures are located together on the same floor level.

Battery of Fixtures: Any group of two or more similar adjacent fixtures which discharge into a common horizontal waste or soil pipe.

Bedding: The material on which the pipe is laid and which provides support for the pipe. Bedding can be concrete, granular material or the prepared trench bottom

Branch:

a) Special form of sewer pipe used for making connections to a sewer or water main. The various types are called 'T', 'Y', 'T–Y', double Y and V branches, according to their respective shapes.

b) Any part of a piping system other than a main or stack.

Branch Soil Pipe: A pipe connecting one or more soil appliances to the main soil pipe.

Branch Soil Waste Pipe: A pipe connecting one or more soil and/or waste appliances to the main soil waste pipe (one pipe system).

Branch Ventilating Pipe: A pipe, one end of which is connected to the system adjacent to the trap of an appliance and the other to a main ventilating pipe or a drain-ventilating pipe. It is fitted to prevent loss of water seal from a trap owing to partial vacuum, back-pressure, or surging caused by air movement within the pipe system. It also provides ventilation for the branch waste pipe.

Branch Waste Pipe: A pipe connecting one or more waste appliances to the main waste pipe.

Branch Discharge Pipe: A common discharge pipe to which plumbing-fixture traps at any one floor level are connected.

Branch Drain: A line or pipes installed to discharge into another line or at a point of access; i.e., a manhole.

Branch Interval: A vertical measurement of distance, 8 feet (2438 mm) or more in developed length, between the connections of horizontal branches to a drainage stack. Measurements are taken down the stack from the highest horizontal branch connection.

Branch Vent: A vent connecting one or more individual vents with a vent stack or stack vent.

Building Drain: That part of the lowest piping of a drainage system that receives the discharge from soil, waste and other drainage pipes inside and that extends 30 inches (762 mm) in developed length of pipe beyond the exterior walls of the building and conveys the drainage to the building sewer.

Building Trap: A device, fitting or assembly of fittings installed in the building drain to prevent circulation of air between the drainage system of the building and the building sewer.

Building Drainage: A drainage system consists of appliances, their traps and discharge pipes, a soil or/and waste stack, graded discharge branch pipes, a building drain and a building sewer with external drains, manholes and other appurtenances.

Building Official: An authority having statutory powers to control design, installation or testing plumbing systems in buildings and their premises.

Building Sewer: That part of the horizontal piping of a drainage system which extends from the end of the building drain to a public sewer, a treatment unit or cesspool.

Cesspool: A covered watertight tank used for receiving and storing sewage from premises which cannot be connected to a public sewer and where ground conditions prevent the use of on-site treatment works including a septic tank.

Chute: A vertical pipe system passing from floor to floor provided with ventilation and inlet openings for receiving refuse from successive floors and ending at the ground floor on the top of the collecting chambers.

Circuit Vent: A vent that connects to a horizontal drainage branch and vents two traps to a maximum of eight traps or trapped fixtures connected into a battery.

Cleanout: A small access opening in a pipe or pipe fitting arranged to facilitate the clearing of obstructions and fitted with removable cap or plug.

Cleaning Eye: An access opening in a pipe or pipe fitting arranged to facilitate the cleaning obstructions and fitted with removable cover.

Code: These regulations, subsequent amendments thereto, or any emergency rule or regulation that the administrative authority having jurisdiction has lawfully adopted.

Combination Fixture: A fixture combining one sink and laundry tray or a two- or three-compartment sink or laundry tray in one unit.

Combination Waste And Vent System: A specially designed system of waste piping embodying the horizontal wet venting of one or more sinks or floor drains by means of a common waste and vent pipe adequately sized to provide free movement of air above the flow line of the drain.

Common Discharge Pipe: See branch pipe

Communication Pipe: That part of the service pipe, extending from the water main up to the water meter (see Figure 1.1)

Common Vent: A vent connecting at the junction of two fixture drains or to a fixture branch and serving as a vent for both fixtures.

Concealed Fouling Surface: Any surface of a plumbing fixture which is not readily visible and is not scoured or cleansed with each fixture operation.

Conductor: A pipe inside the building that conveys storm water from the roof to a storm or combined building drain.

Construction Documents: All of the written, graphic and pictorial documents prepared or assembled for describing the design, location and physical characteristics of the elements of the project necessary for obtaining a building permit. The construction drawings shall be drawn to an appropriate scale.

Consumer: Any person who uses or is supplied water or on whose application such water is supplied by the Authority.

Consumer's Pipe: The portion of service pipe used for supply of water and which is not the property of the Authority (see Figure 1-1).

Cover:

a) A removable plate for permitting access to a pipe, fitting, vessel or appliance.

b) The vertical distance between the top of the barrel of a buried pipe or other construction and the surface of the ground

Cross Connection: Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other either water of unknown or questionable safety or steam, gas or chemical, whereby there exists the possibility for flow from one system to the other, with the direction of flow depending on the pressure differential between the two systems.

Cross vent: A vent interconnecting a stack and its relief vent.

Crown of Trap: The topmost point of the inside of a trap outlet.

Dead End: A branch leading from a soil, waste or vent pipe; a building drain; or a building sewer, and terminating at a developed length of 2 feet (610 mm) or more by means of a plug, cap or other closed fitting.

Depth of Manhole: The vertical distance from the top of the manhole cover to the outgoing invert of the main drain channel

Depth of Water Seal: The depth of water that would have to be removed from a full trap before air could pass through the trap.

Developed Length: A total length along the center line of a pipe and fittings including all bends.

Design Flood Elevation: The elevation of the "design flood," including wave height, relative to the datum specified on the community's legally designated flood hazard map.

Diameter: The nominal internal diameter of pipes and fittings

Discharge Pipe: a pipe for carrying sewage (waste water) from any fixture (appliance) or floor waste fully to a branch (common) discharge pipe, stack or drain.

Distributing Pipe: means any pipe (other than an overflow pipe or a flush pipe) conveying water from a storage cistern or from any other pressure source (apart from main's pressure) to one or more fixtures or appliance (see Figure 1.1).

Domestic Waste: Also known as 'residential waste' consists of wastes produced by household activities such as food preparation, sweeping, cleaning, fuel burning, and gardening. They also can include old clothing, old furnishing, abandoned equipment, packaging and newsprint.

Downpipe: A conduit for the conveyance of roof water from an outlet of a gutter, box receiver or sump to another roof or ground level or storm-water drain.

Drain a pipe installed or laid within the property boundary, intended to convey sewage, storm water, sub-soil water, etc under gravity.

Drain Ventilating Pipe: A pipe installed to provide flow of air to or from a drain to prevent undue concentration of foul air in the drain. The main soil pipe or main waste pipe may serve as drain ventilating pipe wherever their upper portions, which do not receive discharges, are extended to the roof level and let open to air.

Drainage Fittings: Type of fitting or fittings utilized in the drainage system. Drainage fittings are similar to cast-iron fittings, except that instead of having a bell and spigot, drainage fittings are recessed and tapped to eliminate ridges on the inside of the installed pipe.

Drainage Fixture Unit (DFU): A measure of the probable discharge into the drainage system by various types of plumbing fixtures. The drainage fixture-unit value for a particular fixture depends on its volume rate of drainage discharge, on the time duration of a single drainage operation and on the average time between successive operations.

Drainage System: Piping within a public or private premise that conveys sewage, rainwater or other liquid wastes to a point of disposal. A drainage system does not include the mains of a public sewer system or a private or public sewage treatment or disposal plant.

(a) ***Building gravity:*** A drainage system that drains by gravity into the building sewer.

(b) ***Sanitary*****:** A drainage system that carries sewage and excludes storm, surface and ground water.

(c) ***Storm*****:** A drainage system that carries rainwater, surface water, subsurface water and similar liquid wastes.

Drop Manhole: A manhole installed in a sewer where the elevation of the incoming sewer considerably exceeds that of the outgoing sewer; a vertical waterway outside the manhole is provided to divert the waste from the upper to the lower level so that it does not fall freely into the manhole except at peak rate of flow.

Drop Pipe: Vertical section of drain jointing the drains at different levels.

Duct: An enclosure designed to accommodate water pipes and fittings and other services if required and constructed so that access to the interior can be obtained either through its length or at specified points by removal of a cover or covers.

Effluent: Liquid discharged from a waste water treatment unit (process).

E-waste: is a popular informal name for electronic products nearing the end of their "useful life" such as computers, televisions, VCRs, stereos, copiers, fax machines, microwaves and washing machines. Many of these products can be reused, refurbished or recycled. Electronic discards is one of the fastest growing segments of many countries' waste stream. Certain components of these products contain materials that render them hazardous, depending on their condition and density.

Faucet: A valve end of a water pipe through which water is drawn from or held within the pipe.

Fire Hose Reel: A length of fire fighting hose which is connected to a valved water supply and is wound on a reel.

Fire Hydrant: A fitting installed in a water pipeline which provides a valved outlet (above or below ground) to permit a controlled supply of water.

Fittings: Fittings shall mean coupling, flange, branch, bend, tees, elbows, unions, waste with plug, P or S trap with vent, stop ferrule, stop tap, bib tap, pillar tap, globe tap, ball valve, cistern storage tank, baths, water-closets, boiler, geyser, pumping set with motor and accessories, meter, hydrant, valve and any other article used in connection with water supply, drainage and sanitation.

Fixture Unit: A quantity in terms of which the load producing effects on the plumbing system of different kinds of plumbing fixtures is expressed on some arbitrarily chosen scale.

Float Operated Valve: Ball valves or ball taps and equilibrium valves operated by means of a float taken from the pipeline for fire fighting.

Fixture Branch: A drain serving two or more fixtures that discharges to another drain or to a stack.

Fixture Drain: The drain from the trap of a fixture to a junction with any other drain pipe.

Fixture Fitting:

a) Supply fitting- A fitting that controls the volume and/or directional flow of water and is either attached to or accessible from a fixture, or is used with an open or atmospheric discharge

b) Waste fitting- A combination of components that conveys the sanitary waste from the outlet of a fixture to the connection to the sanitary drainage system.

Flushing Cistern: A cistern provided with a device for discharging the stored water rapidly into a water close pan or urinal.

French Drain or Rubble Drain: A shallow trench filled with coarse rubble, clinker, or similar material with or without field drain pipes.

Foul Drainage: The drainage through drains of foul water.

Foul Water: Any water contaminated by soil or any domestic waste water.

Grade (Gradient): The inclination expressed as the percentage of unit rise to horizontal distance.

Gully (Trapped): An assembly used in a waste water system which provides a water seal to prevent odours and gases from escaping into a building or into the atmosphere in the proximity of the assembly.

Hydrant Valve: A valve controlling flow of water from the fire hydrant outlet with provision for attachment of a fire hose.

Horizontal Branch Drain: A drainage branch pipe extending laterally from a soil or waste stack or building drain, with or without vertical sections or branches, that receives the discharge from two or more fixture drains or branches and conducts the discharge to the soil or waste stack or to the building drain.

Horizontal Pipe: Any pipe or fitting that makes an angle of less than 45 degrees (0.79 rad) with the horizontal.

Individual Vent: A pipe installed to vent a fixture trap and connects with the vent system above the fixture served or terminates in the open air.

Inlet Pit: Chamber with an inlet, which may be side entry (herb inlet), granted inlet (gully-grating) or combination, that permits the entry of storm water to a storm water drain and allow access to the drain for maintenance purposes (see Figure H-2, ANNEX H, for kerb and granted inlets).

Inspection Chamber: A covered chamber constructed on a drain or sewer so as to provide access thereto, for inspecting, testing or the clearance and removal of obstructions, and usually situated in areas subjected to light loading only.

Intercepting Trap: A trap used to aerially disconnect the building drain from the sewer.

Interceptor: An appurtenance or device designed and installed so as to separate and retain deleterious, hazardous, or undesirable matter (liquid or solid) from normal waste water and permit normal waste water or liquid waste to discharge into the disposal terminal by gravity.

Junction: A plumbing fitting used to connect a branch pipe or channel to a main pipe or channel.

Leader: An exterior drainage pipe for conveying storm water from roof or gutter drains to an approved means of disposal.

Loading Unit: See **Fixture Unit.**

Local Vent Stack: A vertical pipe to which connections are made from the fixture side of traps and through which vapor or foul air is removed from the fixture or device utilized on bedpan washers.

Manhole: Working chamber with cover constructed on a drain or sewer within which a person may inspect, test or clear and remove obstruction in safety.

Nominal Size (DN): A numerical designation of the size of a pipe, bend or branch fitting, which is a convenient round number approximately equal to a manufactured dimension.

Offset: The pipe and fittings used to provide continuity between pipes whose axes are parallel but not collinear.

Paved Area: an area (a road or path, etc) covered with pointed stones, pointed brick, concrete, asphalt, etc to make a hard and tight surface.

Peak Flow: The maximum rate of a fluctuating flow.

Pipe System: The system to be adopted will depend on the type and planning of the building in which it is to be installed and will be one of the following:

a) *Single stack system (see* Fig.1. 2) — The one pipe system in which there is no trap ventilation.

b) *Single stack — Partially Vented* — A via media between the one-pipe system and the single stack system (see one-pipe system, partially ventilated).

c) *One-pipe system (see* Fig.1. 3) — The system of plumbing in which the wastes from the sinks, baths and wash basins, and the soil pipe branches are all collected into one main pipe, which is connected, directly to the drainage system. Gully traps and waste pipes are completely dispersed with, but all the traps of the water closets, basins, etc, are completely ventilated to preserve the water seal.

d) *One-pipe system — Partially vented (also called single stack, partially ventilated)* — A system in which there is one soil pipe into which all water closets, baths, sinks, and basins discharge. In addition, there is a relief vent, which ventilates only the traps of water closets.

e) *Two-pipe system (see* Fig.1. 4)− The system of plumbing in which soil and waste pipes are distinct and separate. The soil pipes being connected to the drain direct and waste pipes through a trapped gully. All traps of all appliances are completely ventilated in this system.

Pipe Work: Any installation of piping with its fittings.

Puff Ventilation: The ventilation provided for waste traps in two-pipe system, in order to preserve the water seal.

Plumbing: The practice, materials and fixtures utilized in the installation, maintenance, extension and alteration of all piping, fixtures, plumbing appliances and plumbing appurtenances, within or adjacent to any structure, in connection with sanitary drainage or storm drainage facilities; venting systems; and public or private water supply systems.

Plumbing Appliance: Anyone of a special class of plumbing fixtures intended to perform a special function. Included are fixtures having the operation or control dependent on one or more energized components, such as motors, controls, heating elements, or pressure- or temperature-sensing elements. Such fixtures are manually adjusted or controlled by the owner or operator, or are operated automatically through one or more of the following actions: a time cycle, a temperature range, a pressure range, a measured volume or weight.

Plumbing Appurtenance: A manufactured device, prefabricated assembly or an on-the-job assembly of component parts that is an adjunct to the basic piping system and plumbing fixtures. An appurtenance demands no additional water supply and does not add any discharge load to a fixture or to the drainage system.

Plumbing Fixture: A receptacle or device that is either permanently or temporarily connected to the water distribution system of the premises and demands a supply of water there from; discharges wastewater, liquid-borne waste materials or sewage either directly or indirectly to the drainage system of the premises; or requires both a water supply connection and a discharge to the drainage system of the premises.

Plumbing System: Includes the water supply and distribution pipes; plumbing fixtures and traps; water-treating or water-using equipment; soil, waste and vent pipes; and sanitary and storm sewers and building drains; in addition to their respective connections, devices and appurtenances within a structure or premises.

Potable Water: Water which is satisfactory for drinking, culinary and domestic purposes and meets the requirements of the Authority

Ready Access: That which enables a fixture, appliance or equipment to be directly reached without requiring the removal or movement of any panel, door or similar obstruction and without the use of a portable ladder, step stool or similar device.

Registered Design Professional: An individual who is registered or licensed to practice professional architecture or engineering as defined by the statutory requirements of the professional registration laws of Ethiopia

Relief Vent: A vent installed in a stack below the lowest fixture.

Residual Head: The head available at any particular point in the distribution system

Roding: A system of road which are progressively jointed to clear drainage lines.

Roughing Work: The installation of all parts of the plumbing system which is completed prior to the installation of fixtures.

Sand Trap: A chamber (may be a space provided within an inlet pit or a separate pit made for the sole purpose) designed to intercept and retain sand or silt in a storm water drainage system.

Sanitary Fixture: See **Appliance.**

Self-Cleansing Velocity: The velocity of a flowing liquid in a pipe or channel necessary to prevent the deposition of solids in suspension.

Septic Tank: A water-tight receptacle which receives the discharge of a drainage system or part thereof, designed and constructed so as to retain solids, digest organic matter through a period of detention and allow the liquids to be disposed off elsewhere.

Service Pipe: So much of any pipe for supplying water from a main to any premises as is subject to water pressure from that main (see Figure 1.1).

Sewer: A conduit for the carriage of sewage which is usually vested in the local sewerage authority.

Siphonage: The siphoning away of water seals in fixture traps due to negative pressure.

Sleeve*:* An enclosure f tubular or other section of suitable material so designed as to provide a space through an obstruction to accommodate a single water pipe and to which access to the interior can be obtained only from either end of such sleeve.

Soakaway Pit: A pit dug into permeable ground, filled with broken stone, bricks or large granular material and usually covered, where liquid may seep away into the ground.

Soffit: The highest point of the internal surface of a pipe at any cross section.

Soil Appliances: A sanitary appliance for the collection and discharge of excretory matter.

Soil Waste: The discharge from water closets, urinals, slop hopper, stable yard or cowshed gullies and similar appliances.

Sprinkler System: An assembly of pipe work graded in size, erected throughout a building and which sprinkler heads are installed at prescribed intervals. The pipe work is connected to a set of installation (e.g. control valves, etc) for the operation of the system.

Stack: Any vertical waste water drainage or vent pipe including offsets extending through more than one floor level.

Stack Vent: The extension of a soil or" waste stack above the highest horizontal drain connected to the stack.

Stack Venting: A method of venting a fixture or fixtures through the soil or waste stack

Storage Cistern: Any cistern or water tank other than a flushing cistern in which water is stored at atmospheric pressure, the water being normally received through a float control valve set at a predetermined level and incorporating an air gap.

Storm Water Drain: The conduit of a storm water drainage installation normally laid underground for the collection and conveyance of storm water from a premise to the storm water system.

Storm Water Manhole: see **Storm Water Pit.**

Storm Water Pit: A chamber constructed within a storm water drain in order to provide access for inspecting, testing or the clearance of obstructions.

Supply Pipe: So much of any service pipe as is not a communication pipe (see Figure 1.1)

Sub-Soil Water: Water occurring naturally in the sub-soil.

Sub-Soil Water Drain:

(a) A drain intended to collect and carry away sub-soil water.

(b) A drain intended to disperse into the sub-soil from a septic tank.

Surface Water: Natural water from the ground surface, paved areas and roofs

Systems of Drainage:

a) **Combined system-** A system in which foul water (sewage) and surface water are conveyed by the same sewers and drains.

b) **Separate system-** A system in which foul water (sewage) and surface water are conveyed by the separate sewers and drains.

c) **Partially separate system**- A modification of the separate system in which part of the surface water is conveyed by the foul (sanitary) sewers and drains

Trap: Any fitting designed to retain a water seal for the purpose of preventing the passage of gases.

Trap Water Seal: The water retained in a trap which acts as a barrier to the passage of air though the trap.

Trap Weir: The lowest point of the outlet leg of a trap.

Tundish: A fitting into which pipe work can discharge with an air gap.

Under Drain: A two pipe subsurface effluent disposal system with the pipes laid at different elevations, with fine gravel media in between.

Vent Pipe: A pipe installed to provide a flow of air to or from a drainage system or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

Wall-Hung Water Closet: A wall-mounted water closet installed in such a way that the fixture does not touch the floor.

Waste: The discharge from any fixture, appliance, area or appurtenance that does not contain fecal matter.

Water Fittings: Includes pipes (other than mains), taps, cocks, valves, ferrules, meters, cisterns, baths, water closets, soil pans and other similar apparatus used in connection with the supply and use of water.

Water Main (Street Main): A pipe laid by the water undertakers for the purpose of giving a general supply of water as distinct from a supply to individual consumers and includes any apparatus used in connection with such a pipe.

Water Service: That part of the cold water supply pipe work from the water main up to an including the putlet valves at fixtures or appliances.

Water Supplier: Any regional or sub regional water supply organization including water authorities.

Water Supply System: Water supply system of a building or premises consists of the water service pipe, the water distribution pipes, and the necessary connecting pipes, fittings, control valves, and all appurtenances in or adjacent to the building or premises

Waste Appliance: A sanitary appliance for the collection and discharge of water after use for ablutionary, culinary and other domestic purpose.

Waste Pipe: In plumbing, any pipe that receives the discharge of any fixtures, except water closets or similar fixtures and conveys the same to the house drain or soil or waste stack. When such pipe does not connect directly with a house drain or soil stack, it is called an indirect waste pipe.

Water Seal: The water in a trap, which acts as a barrier to the passage of air through the trap.

Yoke Vent: A pipe connecting upward from a soil or waste stack to a vent stack for the purpose of preventing pressure changes in the stacks.

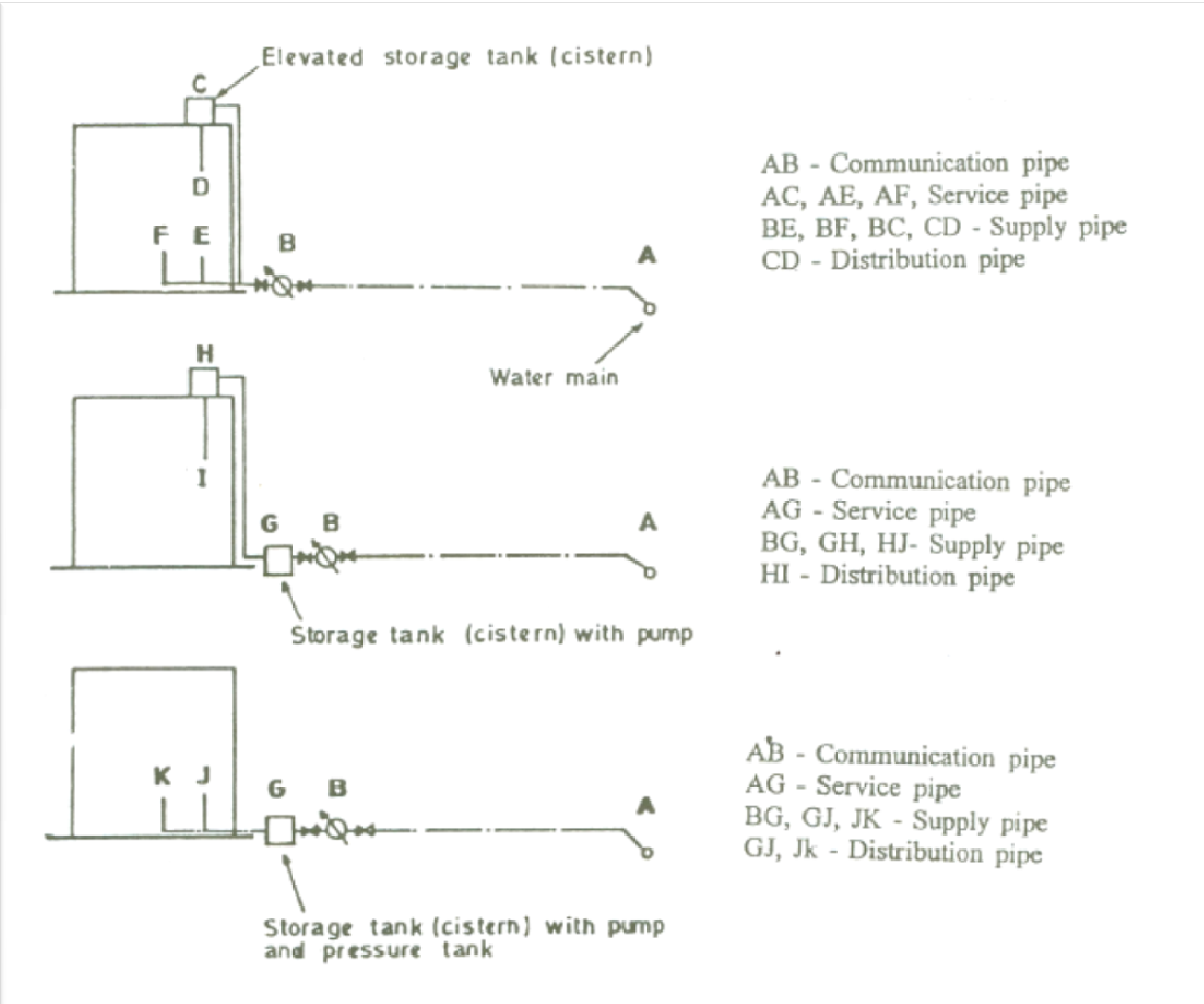


Figure 1-1 Domestic water service connections

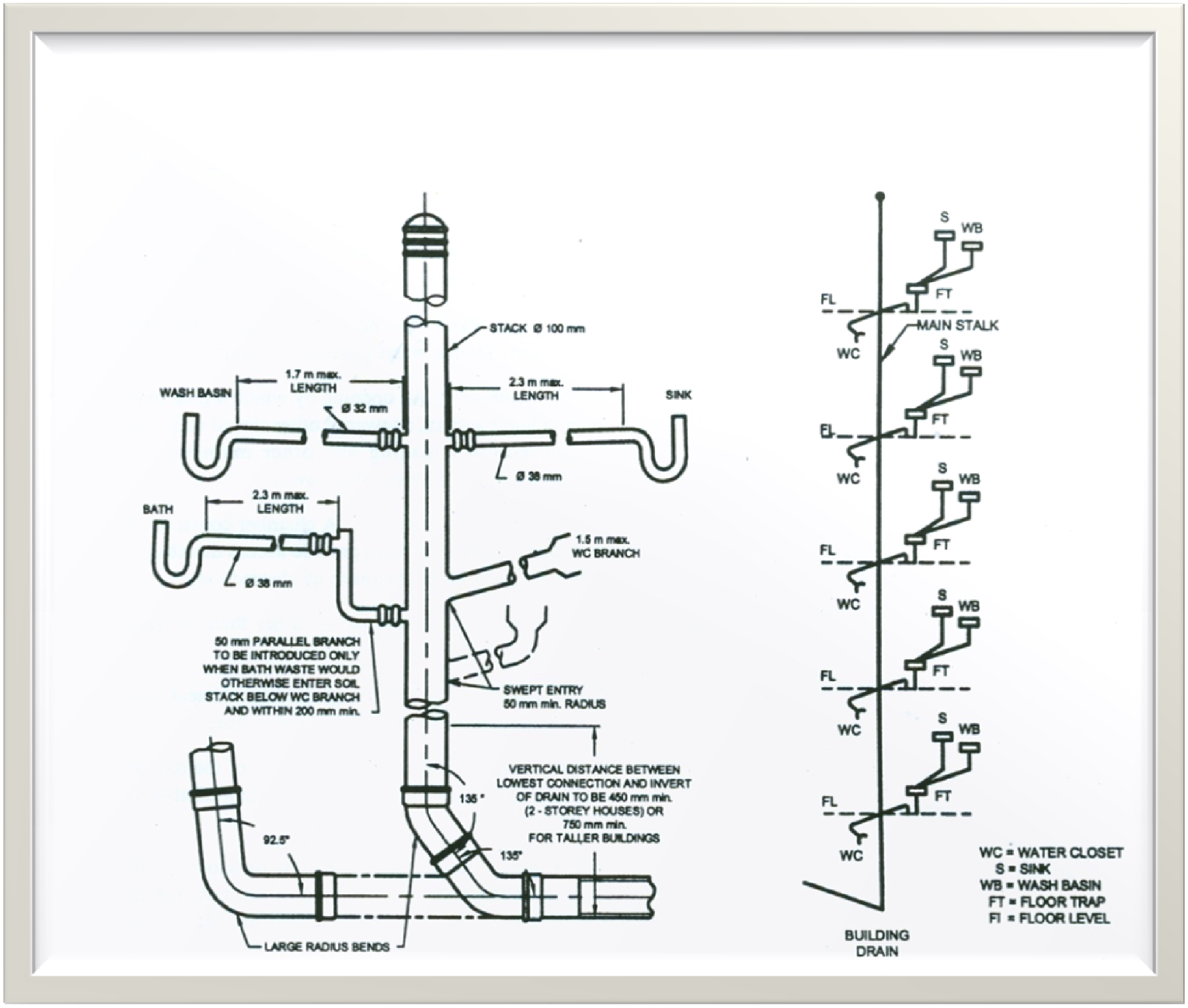


Figure 1-2 Single Stack System--Main Feature OF Design

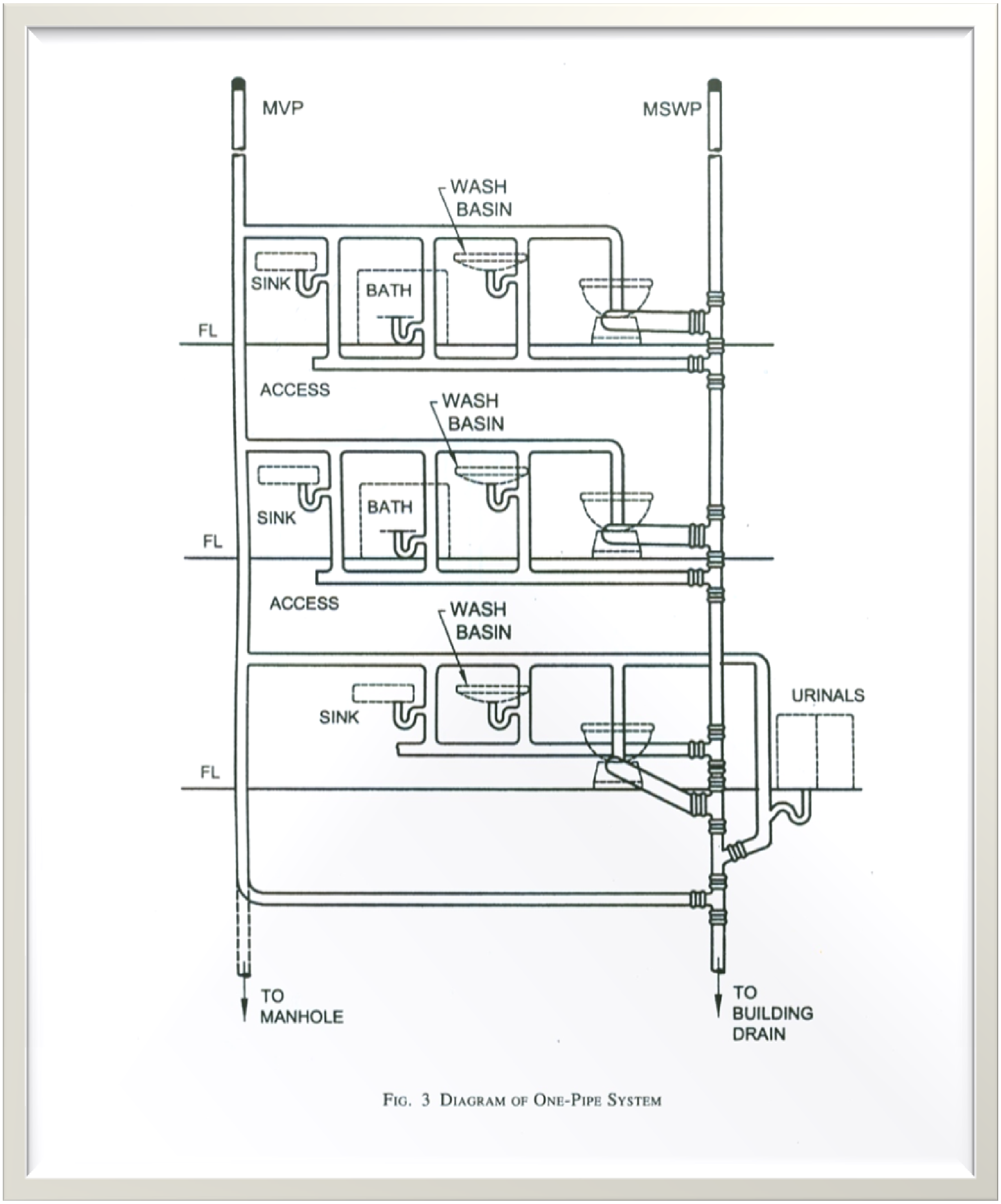


Figure 1.3 Diagram of One-Pipe System

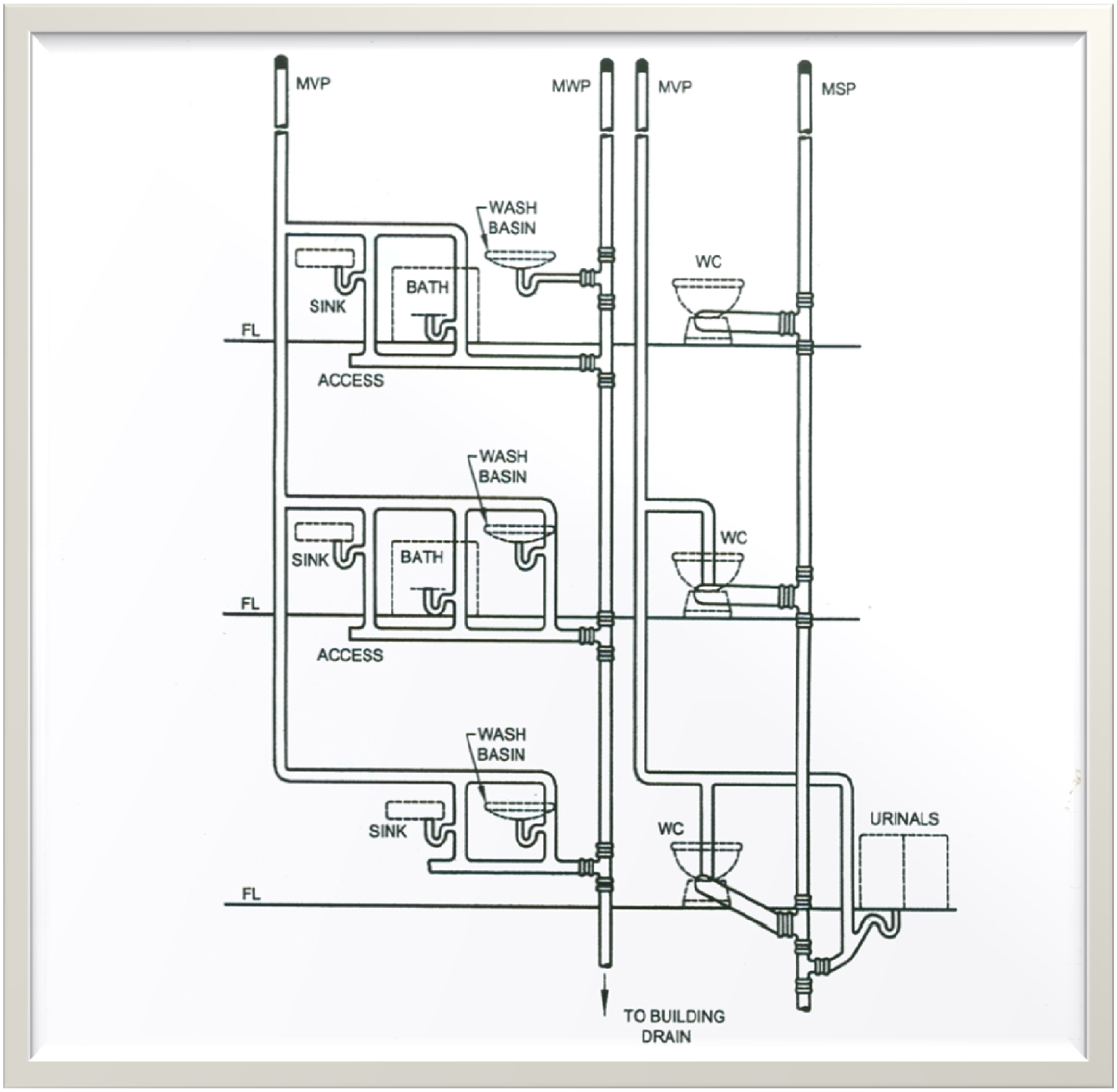


Figure 1-4 Diagram of Two-Pipe System

SECTION 2

2 ADMINISTRATION

2.1 The Authority

The Ministry of Urban Development and Construction, the Authority which has been created by a statute and which, for the purpose of administering the Code/Part, may authorize a committee or an official or an agency to act on its behalf, hereinafter called **the 'Authority'**.

2.2 Permits for Connections

2.2.1 Water Supply Connection

2.2.1.1 Application for obtaining supply connection

Every consumer, requiring a new supply of water or any extension or alteration to the existing supply shall apply in writing in the prescribed form (see Annex A) to the Authority.

2.2.1.2 Bulk supply

In the case of large housing colonies or where new services are so situated that it will be necessary for the Authority to lay new mains or extend an existing main, full information about the proposed housing scheme shall be furnished to the Authority; information shall also be given regarding their phased requirements of water supply with full justification. Such information shall include site plans, showing the layout of roads, footpaths, building and boundaries and indicating there on the finished line and level of the roads or footpaths and water supply lines and appurtenances.

2.2.1.3 Completion certificate

On completion of the plumbing work for the water supply system, the licensed plumber shall give a completion certificate in the prescribed form (see Annex B) to the Authority for getting the water connection from the mains.

2.2.2 Drainage and Sanitation

2.2.2.1 Preparation and submission of plan

No person shall install or carry out any water-borne sanitary installation or drainage installation or any works in connection with anything existing or new buildings or any other premises without obtaining the previous sanction of the Authority. The owner shall make an application in the prescribed form (see Annex C) to the Authority to carry out such a work.

2.2.2.2 Site Plan

A site plan of the premises on which the building is to be situated or any such work is to be carried out shall be prepared drawn to a scale not smaller than 1:500. The site plan of the building premises shall show:

(a) the adjoining plots and streets with their names;
(b) the position of the municipal sewer and the direction of flow in it;
(c) the invert level of the municipal sewer, the road level, and the connection level of the proposed drain connecting the building in relation to the sewer,
(d) the angle at which the drain from the building joins the sewer; and
(e) the alignment, sizes and gradients of all drains and also of surface drains, if any.

A separate site plan is not necessary if the necessary particulars to be shown in such a site plan are already shown in the drainage plan.

2.2.2.3 Drainage Plan

The application (2.2.2.1) shall be accompanied by a drainage plan drawn to a scale of not smaller than 1:100 and furnished along with the building plan. The plans shall show the following:

(a) Every floor of the building in which the pipes or drains are to be used;
(b) The position, forms, level and arrangement of the various parts of such building, including the roof thereof;
(c) All new drains as proposed with their sizes and gradients;
(d) Invert levels of the proposed drains with corresponding ground levels;
(e) The position of every manhole, gully, soil and waste pipe, ventilating pipe, rain water pipe, water-closet, urinal, latrine, bath, lavatory, sink, trap or other appliances in the premises proposed to be connected to any drain and the following colors are recommended for indicating sewers, wastewater pipes, rainwater pipes and on existing work.

Description of Work	**Color**
Sewers	Red
Wastewater pipes and rain-water pipe	Blue
Existing work	Black

(f) The position of refuse chute, inlet hopper and collection chamber.

2.2.2.4 In the case of an alteration or addition to an existing building, this clause shall be deemed to be satisfied if the plans as furnished convey sufficient information for the proposals to be readily identified with previous sanctioned plans and provided the locations of tanks and other fittings are consistent with the structural safety of the building.

2.2.2.5 The plans for the building drainage shall in every case be accompanied by specifications for the various items of work involved. This information shall be supplied in the prescribed from given in Annex D.

2.2.2.6 In respect of open drains, cross-sectional details shall be prepared to a scale not smaller than 1:50 showing the ground and invert levels and any arrangement already existing or proposed for the inclusion of any or exclusion of all storm water from the sewers.

2.2.2.4 Completion Certificate

At the completion of the plumbing installation work, the licensed plumber shall give a completion certificate in the prescribed form, which is given in Annex E.

2.3 Licensing/Registration of Plumbers

2.3.1 Execution of Work

The work which is required to be carried out under the provisions of this Section shall be executed only by a licensed plumber under the control of the Authority and shall be responsible to carry out all lawful directions given by the Authority. No individual shall engage in the business of plumbing unless so licensed under the provisions of this Section.

2.3.1.1 No individual firm, partnership or corporation shall engage in the business of installing, repairing or altering plumbing unless the plumbing work performed in the course of such business is under the direct supervision of a licensed plumber.

2.3.2 Examination and Certification

The Authority shall establish standards and procedure for the qualification, examination and licensing of plumbers and shall issue licenses to such persons who meet the qualifications thereof and successfully pass the examination.

2.3.3 Duration of the License

All licenses issued by the Authority shall be valid for a period of minimum two years and shall expire on the date indicated on the license, but may be renewed, upon payment of fees prescribed by the Authority, for further period of two years each, at a time the expired license not renewed within prescribed time of the expiry of the license may he renewed upon payment of the penalty prescribed by the Authority.

2.3.4 Revocation or Suspension of License

The Authority may suspend or revoke any license for non- compliance of the conditions under which the license has been given, or breach of any regulations of the water supply undertaking. Before a license may be suspended or revoked, the licensee shall have notice in writing, enumerating the charges against him, and be entitled to a hearing by a duly authorized board or officer of the Authority. The licensee shall be given an opportunity to present testimony, oral or written, and shall have the right to cross- examination. A person whose license has been revoked shall not be permitted to reapply for a license within two years from the date of revocation.

2.4 Control of Licensed Plumbers

2.4.1 Inspection

The officer deputed by the Authority may inspect at any time without notice any work done by licensed plumber or place of business.

2.4.2 Payment of All Lawful Charges

Every licensed plumber shall pay lawful demands made by the Authority for:

a) Repairs to roads, drains, pipes, mains or any fittings or appliances connected therewith or any other property whatsoever whether belonging to the Authority or not;
b) Losses made to any person or property by or through neglect ;
c) Fees for licenses for the time being in force for carrying out trades.

2.4.3 No Work Should be done without Permission

No licensed plumber shall make any water connection or any addition or alteration in fittings and appliances to carry out any other work in or with reference to public streets, pipes, sewers, drains, without obtaining sanction of the Authority.

2.4.4 Pipes and Fittings to be Approved

In execution of any work, the pipes, fittings, appliances and material used shall conform to relevant Ethiopian Standards or approved by the Authority.

2.5 Obligations of Licensed Plumber

2.5.1 Every licensed plumber shall proceed with any work undertaken by him diligently and in a proper workman like manner and shall not cause any delay in the execution thereof without sufficient cause.

2.5.2 Every licensed plumber shall report to the Authority defect noticed by him in any premises in connection with any water pipes, fittings or other appliances causing waste of water or in connection with any drains, water closets, privies, urinals or any fittings, appliances connection therewith rendering such drains privy or urinal insufficient or otherwise objectionable for sanitary reasons.

SECTION 3

3 SANITARY FIXTURES

3.1 Scope

(1) This section deals with the selection, installation, and maintenance of sanitary fixtures.

3.2 Materials

3.2.1 Quality

(1) Sanitary fixtures shall have smooth impervious surfaces, be free from defects and concealed fouling surfaces and shall be of approved standards in quality and design (see Clause 3.2.2).

3.2.2 Standards to be Complied With

(1) All sanitary fixtures shall comply with the relevant Ethiopian Standards or equivalent and shall be acceptable on the approval of the Building Official.

3.2.3 Delivery and Storage

(1) Before deliver, arrangement should be made for storage of fixtures under cover to prevent damage.

(2) Upon delivery, all fixtures should be checked carefully to ensure that they satisfy provisions of Section 3.2

(3) Handling and storage of fixtures shall confirm to the manufacturer's and/or supplier's interaction.

(4) All accessories such as traps, taps, brackets, seats, cisterns, etc should be checked and, if appropriate, grouped together.

3.3 Design Considerations

3.3.1 Sanitary Accommodation

(1) (a) Adequate ventilation of all sanitary accommodation including bath rooms and kitchens should be provided.

(b) Windows or sky light opening direct to the external air should be made wherever possible.

(c) Where natural ventilation is not possible, mechanical ventilation in accordance with the provisions of EBCS-11.

(2) (a) Care should be taken to prevent the transmission of noise from sanitary fixtures to areas such as sitting rooms, class rooms and public areas.

(b) Noise can be reduced by proper attention to pipe work, siting and fixing of the fixture.

(3) Bath and shower compartments shall have walls constructed of smooth, non-corrosive and non-absorbent waterproof material to a height of non less than 1.8m above the floor.

3.3.2 Fixture

(1) Fixtures should be selected and installed to allow all connections to be correctly made initially and so as to be easily disconnected for subsequent maintenance or replacement.

(2) Where fixtures will be subjected to heavy use, as in public conveniences, schools, hospitals, factories, etc, they should be robust in construction and designed to withstand misuse.

3.3.3 Hygiene

(1) (a) Sanitary fixtures should be designed, assembled and fitted so as to avoid harbouring dirt.

(b) Where fixtures abut a floor and/or a wall or walls, the joint between the fixtures and the floor and/or the walls should be impermeable.

(2) Shower traps and surrounding areas should be cleansable specially in the case of communal showers.

(3) (a) Sanitary fixtures should be installed in a manner to afford easy access for cleaning.

(b) Fixtures having concealed slip-joints connections should be provided with an access for or unity space so arranged as to make the slip connection accessible for inspection and repair.

3.3.4 Support

3.3.4.1 General

(1) The design, choice and fixing of supports for sanitary fixtures are important and consideration should be given to the dead weight of fixtures the load which may be placed in it or on it and the nature of the structure to which it is to be fixed.

(2) All fixing screws should be of non-ferrous metal or stainless steel, and any low-carbon steel in brackets or other supports should be galvanized, whether subsequently painted or not.

3.3.4.2 Brackets

(1) Brackets should be of adequate strength and securely fixed having regard to the cantilever effect of the weight of the fixture fully loaded.

3.3.4.3 Floor supports

(1) Larger and heavier sanitary fixtures, such as ablution fountains, shall be fixed direct to the floor. Great care should also be taken to ensure that they are bedded solidly on a level and even base.

(2) Other lighter fixtures such as WC pans and pedestal wash basins shall also be fixed direct to the floor on a level and even base.

(3) Appliances on pedestals or legs shall be fastened to walls to give stability, expect in those cases where the whole fitting is designed to be self supporting.

3.4 Provision of Fixtures (Appliances)

(1) The scale of provision of sanitary fixtures for the various types of occupancies shall be as specified in NBCE Part 6.

3.5 Selection and Installation of Fixtures

3.5.1 General

(1) Care should be taken at all times, and particularly after fixing, to protect fixtures from damage. Glazed, enameled and plated surfaces of fixtures can be irreparably damaged by carelessness during subsequent operations.

(2) Water supply and discharge pipes should be installed before fixtures are put in place. Before installing fixtures, it should be ensured that the discharge pipe is clear or obstruction. Joints between fixtures and traps and/or pipes should be of the union or detachable type.

(3) Cistern overflows should be arranged to give visible warning of discharge.

3.5.2 Bath-tubs

3.5.2.1 Selection

(1) Bath-tub is intended for bodily immersion in a reclining position and it should have a flat bottom with a fall to the outlet.

(2) Anti-slip surfaces, if provided, should not interfere with comfort or ease of cleaning and draining.

3.5.2.2 Installation

(1) Support should be adequate for the weight of the fixture, use and water and sufficiently unyielding to obviate strain on service connections.

(2) Supports should be adjustable to permit a bath-tab should be horizontal and care should be taken to make a permanently watertight seal between the wall and the edge of the bath.

3.5.3 Shower Units

3.5.3.1 Selection

(1) Bodily ablutions under running water are more hygienic than washing by bodily immersion in a bath. In addition, a shower unit is more economical in energy and water consumption and convenient to use.

(2) Shower units shall be selected in accordance with approved standard (see Section 3.2).

3.5.3.2 Installation

(1) (a) Shower units should be installed in rooms that are adequately ventilated to reduce the possibility of condensation.

(b) Adequate space should be provided to ensure convenience in use.

(c) Shower trays should be laid on a smooth and structurally sound base and shall be and made watertight with acceptable material.

(2) (a) Public shower rooms shall be drained in such a manner that no waste water from any head will pass over areas occupied by other users.

(b) Traps shall be constructed so that a shower tray may be securely fastened to the trap at the seepage entrance, making a watertight joint between the shower tray and the trap.

3.5.4 Bidets

3.5.4.1 Selection

(1) There are two main types of bidets – over-rim water feed and submersible spray.

(2) Either of the bidets in (1) above may be with pedestal (more frequently fitted), or wall mounted (used where an unrestricted floor is required).

3.5.4.2 Installation

(1) Pedestal bidets should be set on a level floor or bed.

(2) Where fixing screws are used, they should be non-ferrous or stainless steel.

(3) Wall-hung type bidets may be fixed directly to load bearing walls by bolts or, alternatively and for non-load bearing walls, by bolting to a support frame.

3.5.5 Sinks

3.5.5.1 Selection

(1) The most hard-wearing material for sinks is stainless steel. Fire-clay sinks are hard-wearing and strong, but care has to be taken in the use of utensils to avoid chipping, especially on the front edge of the sink. Enamel steel sinks require careful use to prevent chipping the enamel.

3.5.5.2 Installation

(1) Sinks fitted as an independent fixture shall be supported on cantilever brackets, wherever possible, in order to avoid the use of leg supports.

(2) Where sinks are built into table-top units, care shall be taken to seal the joint between the bowl rim and the surrounding to prevent water seeping below the surface of the table top.

3.5.6 WC Pans

3.5.6.1 Selection

(1) (a) A single flushing should clear all normal faecal matter from the WC pan, the flush being so distributed over the internal surface of the pan as to cleanse every part thereof without any of the contents of flushing water splashing on to the seat or the floor.
(b) WCs should be selected so that noise produced while flushing is minimum.

(2) Wash down WC pans have horizontal outlets and require purpose-made connector to connect them to the drainage systems.

(3) Siphonic WC pans depend upon siphonic action generate in the trap for the removal of the contents when flushed. The area of exposed water in siphonic pans is usually greater than in the washdown type with less chance of the pan being soiled. Siphonic WC pans have a quieter flush than washwoen types but are more prone to blocking.

(4) Squatting WC pans are designed to be used without a seat and consist of a floor level bowl with a squatting plate, i,e impervious surround which normally has slightly raised foot treads.

3.5.6.2 Installation

(1) To prevent the penetration of moisture, the joint between the underside of the WC pedestal and the floor should be sealed.

(2) All pedestal-type WC pans should be secured to the floor using stainless steel or non-ferrous fixing screws.

(3) Where pedestal WC pans are installed on solid floors, it is essential that provision be made in the floor to receive the fixing screws.

(4) If cement mortar is used for bedding (normally 1:3 mix), a thin layer should be applied only to that part of the pedestal which is in contact with the floor.

(5) Wall-hung type WC pans may be fixed directly to load bearing walls by bolts, or alternatively and for non-load bearing walls, by bolting to a support frame.

3.5.7 WC Seats and Covers

3.5.7.1 Selection

(1) WC seats and covers should be smooth and non absorbent. Ring sears are the simplest type of seats and the most suitable for general use.

(2) Open-front seats are mostly used in male sanitary blocks in such buildings as industrial and commercial premises and public conveniences, as being less likely to be fouled than ring seat.

3.5.7.2 Installation

(1) The seat and cover, where fitted, should be properly fixed direct to the WC pan with hinges. Compressible protective washers should be used between the hinge fixings and both sides of the ceramic-ware. When raised, all seats and covers should travel though an angle greater than 90^0 to ensure stability.

3.5.8 Flushing Cisterns for WCs

3.5.8.1 Selection

(1) Flushing cisterns shall have a flushing capacity sufficient to properly flush WC bowls with which they are connected.

(2) The float-operated valve should close tight and be selected to suit the water pressure and to ensure a refilling time of not longer than 2.0 min,

3.5.8.2 Installation

(1) Flushing cisterns may be:

(a) Supported by direct wall fixing; or
(b) Supported by brackets of various types; or
(c) Close coupled to WC pan.

3.5.9 WC Flush Pipes

(1) A 32.0mm minimum inside diameter flush pipes is required for high level cistern and a

3.5.10 WC Flush Valves

(1) Flush valves should be installed so that they will be readily accessible for maintenance.

(2) When the value is operated, it shall complete the cycle of operation automatically, opening fully and closing positively under the service pressure.

(3) At each operation, the value shall deliver water in sufficient volume and at a rate that will thoroughly flush the fixture and refill the fixture trap.

(4) Means shall be provided for regulating the flush valve flow.

(5) Not more than one fixture shall be served by a single flush valve.

3.5.11 Urinals

3.5.11.1 Selection

(1) (a) Still urinal is heavy, takes up more space, and unless designed with great care with all angles rounded, it is more difficult to keep clean.

(b) it affords greater privacy than other types and is better able to withstand rough usage.

(c) Flushing should be by means of a spreader to each stall to clean the whole surface likely to be fouled.

(2) (a) Bowl urinal are less restrictive to planning and are more suitable for use where floor movement might occur.

(b) Spreader should be provided to ensure that the flushing water washes the whole of the internal surface of the bowl likely to be fouled.

(c) Bowl urinals are recommended only where responsibility in use can be anticipated, as they are vulnerable to misuse.

(d) Independent divisions securely bolted to the wall surface should be used for privacy.

(3) (a) Trough urinals should be rigidly supported along the whole of their length and should discharge to a trapped outlet.

(b) Flushing may be by spreader to other means which can produce an even curtain of water against the back of the urinal.

(c) Trough urinals shall be smooth and non absorbent.

3.5.11.2 Installation

(1) The area behind, under and around urinals should be carefully made (made smooth and non-absorbent) to take into account water and urine penetration.

(2) (a) The maximum fun of channel (through urinal) to an outlet should not exceed 2400.0mm.

(b) The floor surface should be non-slip and hard wearing.

(c) Trough urinal should preferably be made so that the front lip is 600.0mm high for men on 500.0mm high for junior boys.

3.5.12 Wash Basins

3.5.12.1 Selection

(1) Vitreous China basins serve most purposes.

(2) Fire clay can be used, but is subject to the disadvantage of chipping, and it usually needs replacement.

(3) Stainless steel gives good service under most conditions.

(4) Porcelain channeled sheet steel is suitable for light duty, but better service is usually obtained from porcelain channeled cast iron for normal and heavy duty.

3.5.12.2 Installation

(1) The following types of support are normally used for the installation of wash basins;

(a) Wall fixing by means of built-in cantilever or brackets, screwed brackets, or by screwing direct to the wall.

(b) A pedestal securely fixed to the floor. The basin should be properly bedded on the pedestal and anchored to the wall. It may be advisable to carry the weight of the basin on wall fixings.

(c) Insert into a table top. Care should be taken to seal the joint between the rim and the surround to prevent water seeping below the surface of the table top.

3.5.13 Floor Drains (Floor Waste Gullies)

(1) Floor drains shall be rust-resistant and provided with removable strainers or gratings

(2) Floor drains shall be of a size to serve sufficiently the purpose for which they are intended (see Clause 5.8.3.6.2).

3.6 Inspection and Maintenance

3.6.1 Inspection

(1) Upon completion of the work, all fixtures, materials and workmanship should be carefully examined for defects and for faults in installation which should be corrected before the fixtures are handed over for use.

3.6.2 Maintenance

3.6.2.1 General

(1) Fixture should be cleaned frequently to maintain them in good sanitary condition and to preserve their appearance.

(2) The removal of faulty tap and valve washers should receive prompt attention to avoid waste of water and damage to the value seating and the surface of the fixture.

(3) Cleaning materials containing corrosive alkalis, abrasives or acids should not be used because they damage fixtures and/or discharge pipe.

(4) The instruction of the manufacturer of the fixtures and of the cleaning and/or de-scaling materials should be followed.

3.6.2.2 Removal of scale and encrustation

(1) For the removal of scale, encrustation and other deposits, acid and alkali-based cleaning materials should be used with caution to avoid damage to the appliance and pipework and/or injury to the cleaning operatives.

SECTION 4

4 WATER SUPPLY AND DISTRIBUTION

4.1 Scope

(1) This section covers basic requirements of water supply and distribution for residential, commercial and other types of buildings, including traffic terminal stations and gives recommendations on the design, installation, testing, commissioning and maintenance of water supply and distribution services.
(2) It covers the system of pipes, fittings and connected appliances (fixtures) installed to supply buildings.
(3) This section deals only with low temperature systems; it does not cover systems that are designed to operate with steam or high temperature hot water.
(4) This section does not take into consideration the requirements of water supply for industrial plants and processes and other purposes.

4.2 Materials

4.2.1 General

(1) The plumbing system shall have durable material, free from defective workmanship and so designed and installed as to give satisfactory service for its reasonable expected life.
(2) Materials that have been used for a purpose other than the distribution of potable water shall not be subsequently used in a potable water system.
(3) Every length of pipe and every fitting shall have case, stamped or indelibly marked on it the maker’s name or mark and the weight or class or quality of the product, or it shall be marked in accordance with the relevant standard; and such markings shall be visible after installation.
(4) Water distribution pipes and fittings shall be of brass, copper, cast iron, UPVC, galvanized malleable iron, galvanized wrought iron, and galvanized steel, PEX, PPR or other approved materials manufactured to recognized standards may be used for water distribution system. All materials used in the water supply system, except valves and similar devices, shall be of a like material, unless and otherwise approved by the Authority Having Jurisdiction.

4.2.2 Pipes and Fittings

4.2.2.1 Standards to be complied

(a) All pipes and fittings for the water supply system shall comply with the relevant Ethiopian Standards or equivalent standards approved by the Building Official.

4.2.2.2 Specific Requirements

(1) Lead

(a) No pipe or pipe fittings or storage cistern made from lead or internally lined with lead shall be used in new installations.
(b) Repairs to existing lead services shall be by replacement with other approved materials.
(c) The repair or partial replacement of lead piping with copper piping shall be avoided unless galvanic action is prevented.

(2) Copper

(a) Copper is generally resistant to corrosion and is suitable for hot and cold water applications. Where supply waters are capable of dissolving an undue amount of copper such that either:
   i. Unacceptable green staining is produced, or
   ii. Deposition of copper into aluminum or zinc surface promotes galvanic attack; consideration shall be given to the use of alternative materials.
(b) Galvanized steel pipe work should not be used connected to and, especially, downstream from copper pipe work; otherwise it will be subjected to accelerated corrosion.

(3) Galvanized steel

(a) Galvanized steel pipe shall be jointed only by screwed connections; under no circumstances shall welded or brazed joints be used because this would damage the galvanizing. Site bending of galvanized tube will also damage the galvanizing; in view of this or where it is necessary to change direction pre-formed bends shall be used. Galvanized tubes offer only marginal protection against corrosion, and shall be protected from corrosion especially where installed below ground.

(4) Plastic pipes

(a) Plastic pipes shall not be installed close to source of heat or in direct sunlight; otherwise their performance is impaired.
(b) Where pipes are installed above ground, consideration shall be given to accommodate thermal movements.
(c) As un-plasticized PVC pipes become increasingly brittle with reducing temperatures, particular care should be taken in handling them in temperatures below 5^0C.

(5) Coating and lining materials

(a) No pipe, pipe fitting or storage cistern intended for conveying or storing water shall be lined or coated internally with coal, tar or any substance that includes coal-tar.
(b) Recommendations for the protective coating against corrosion of iron and steel pipes, fittings and cisterns shall be referred to approved standards.

4.2.3 Materials Handling and Preparation

(1) Materials installed in the system shall be so handled and installed as to avoid damages so that the quality of the material will not be impaired.

(2) Check delivery documents and certificates against specification; examine marks and labels and condition of materials and components.

(3) Handle all materials and components with appropriate care to prevent damage, soiling and contamination.

(4) Store materials and components
   (a) in a secure shelter or compound under cover and on bases or racking prepared in advance of deliveries.
   (b) in accordance with manufacturer's instructions
   (c) protect polyethylene or any plastic tube and pipe from direct sunlight.
   (d) in the protective wrappings or carton in which they are delivered.

(5) Preparation Work
   (a) Communicate to establish and agree the positions of pipe work and fittings in relation to other services, appliances, and any requirements for first and subsequent fixing stages.
   (b) Inspect all components immediately before assembly and discard any components that are damaged.

4.2.4 Choice of Materials

(1) The following factors shall be taken into account in selecting materials to be used in a water service:
   (a) Cost,
   (b) Effect on water quality,
   (c) Internal and external corrosion,
   (d) Compatibility of different materials,
   (e) Ageing, fatigue and temperature effects,
   (f) Mechanical properties,
   (g) Durability.

(2) Every part of a water installation shall be cable of operating effectively under the conditions which it will experience in service. Accordingly;
   (a) Every pipe, pipe joint and connected fitting used for domestic water supply shall be capable of withstanding, without damage or deterioration, sustained temperature of up to 40^0C for cold water installation and up to 70^0C, with occasional short-term excursions up to 100^0C to allow for malfunctions, for heated water installations.
   (b) Every draw-off tap shall be capable of operating effectively at any water temperature and internal water pressure to which it is to be subject.
   (c) Discharge pipes connected to temperature or expansion relief valves shall be capable of withstanding any continuous hot water or steam discharge at temperatures up to 125^0C.

(3) (a) If pipes, pipe joints or connected fittings are of dissimilar metals, necessary measures shall be taken to prevent corrosion.

(b) Dissimilar metals should be avoided in below-ground installation wherever practicable.

4.3 Water supply

4.3.1 General

(1) Any cold water tap which is likely to be used for drinking water and all such taps not connected directly to the potable water supply mains shall be supplied from a storage cistern which is protected in accordance with clause 4.3.4.

(2) No drinking water point shall be installed at the end of a long pipe where only small volumes of water are drawn-off.

(3) To reduce the risk of stagnation, the layout of the pipe work should be arranged, where possible, so that fittings downstream of a drinking water point have a high demand**.**

(4) All premises intended for human habitation, occupancy, or use shall be provided with supply of potable water. This water supply shall not be connected with unsafe water resources, nor shall it be subject to the hazards of backflow.

(5) Plumbing fixtures, devices and appurtenances shall be provided with water in sufficient volume and at pressures adequate to enable them to function properly and without undue noise under normal conditions of use. There should be at least a residual head of 0.5 bar (5 m) at the consumer’s tap at critical water outlet and whenever fixtures or fixture fittings that require a residual pressure higher than 0.5 bar are installed, that minimum residual pressure shall be provided.

(6) Plumbing system shall be designed, installed and adjusted to use the optimum quantity of water consistent with proper performance and cleaning.

4.3.2 Quality of Water supply

4.3.2.1 General

(1) Public water suppliers are obliged to provide a supply of wholesome water which is suitable and safe for drinking and culinary or cooking purposes.

4.3.2.2 Potable Water

(1) Potable water is water which is satisfactory for drinking, culinary and other domestic purposes. The quality of water to be used for this purpose shall be as per the prevailing standards at the time of application. The national drinking water quality standard for Ethiopia is shown in Table 4-1. WHO drinking water guideline values for chemicals that have health significance are also indicated in Annex K.

Table 4-1 Ethiopian Drinking Water Quality Standard (ES 261:2001)

Parameter	Unit	Maximum permissible level
PHYSICAL		
Odor	-	Unobjectionable
Taste	-	Unobjectionable
Turbidity	NTU	5
Color	TCU	15
CHEMICAL		
Total hardness	mg/L as $CaCO_3$	300
Total dissolved solids	mg/L	1000
Total iron	mg/L	0.3
Manganese	mg/L	0.01
Ammonia (NH_3+$NH4^+$)	mg/L	1.5
Residual free chlorine	mg/L as MBAS	0.5
Anionic surfactants	mg/L	1.0
Magnesium	mg/L	50
Calcium	mg/L	75
Copper	mg/L	2
Zinc	mg/L	5
Sulfate	mg/L	250
Chloride	mg/L	250
Total alkalinity	mg/L	200
Sodium	mg/L	200
Potassium	mg/L	1.5
Aluminum	mg/L	0.2
pH	-	6.5-8.5
Barium	mg/L	0.7
Total mercury	mg/L	0.001
Cadmium	mg/L	0.003
Arsenic	mg/L	0.01
Cyanide	mg/L	0.07
Nitrite	mg/L	3
Nitrate	mg/L	50
Phenolic compounds as phenol	mg/L	0.002
Lead	mg/L	0.01
Boron	mg/L	0.3
Selenium	mg/L	0.01
Fluoride	mg/L	1.5
Chromium	mg/L	0.05
Pesticides	mg/L	2
Lindane	mg/L	0.03
Aldrin/Dieldrine	mg/L	30
1,2 Dichloroethane		
BACTERIOLOGICAL		
Total viable organisms	Colonies per 100 mL	Must not be detectable
Faecal streptococci	MPN per 100 mL	Must not be detectable
Coliform organisms	MPN per 100 mL	Must not be detectable
E.Coli	MPN per 100 mL	Must not be detectable

4.3.2.3 Non-Potable Water

(1) Non-potable water may be used for flushing water closets and urinals and other appliances not requiring potable water, provided such water shall not be accessible for drinking or culinary purposes.

4.3.3 Identification of Potable and Non Potable Water System

(1) In buildings where dual water distribution systems are installed, one potable and the other Non-potable water, each system shall be identified either by color code or metal tags, or other appropriate methods as may be approved by the Authority Having Jurisdiction. Each outlet on the non-potable water line that may be unknowingly used for drinking or domestic purpose shall be posted: **DANGER - UNSAFE WATER.**

(2) Potable and Non potable water systems installed shall be clearly identified by the following color code.

a) Potable water - Green background with white lettering.

b) Non potable – Yellow background with black lettering , with words

"Caution: Non-potable water"

c) Each system shall be identified with a colored band to designate the liquid being conveyed , and the direction of normal flow shall be clearly shown. The minimum size of the letters and length of the color field shall confirm to Table 4.2.

d) A colored identification band shall be indicated every 6 meters, but at least once per room and shall be visible from the floor level.

Table 4-2 Minimum Length of Color Field and Size of Letters

Minimum Length of Color Field and Size of Letters

Outside Diameter of Pipe or Covering inches	(mm)	Minimum Length of Color Field inches	(mm)	Minimum Size of Letters inches	(mm)
1/2 to 1-1/4	(15 to 32)	8	(203)	1/2	(12.7)
1-1/2 to 2	(40 to 50)	8	(203)	3/4	(19.1)
2-1/2 to 6	(65 to 150)	12	(305)	1-1/4	(32)
8 to 10	(200 to 250)	24	(619)	2-1/2	(64)
Over 10	(Over 250)	32	(813)	3-1/2	(89)

Source: Uniform Plumbing Code, 2003 – Table 6-1 page 91

4.3.4 Preservation qf Water Quality

4.3.4.1 General

(1) Water supply installations shall be carried out so that delivered water is not liable to become contaminated to the extent that it is hazardous to health or is unfit for its intended use.

(2) The installation in (1) above, in particular, shall not adversely affect drinking water in any of the following ways;

(a) By materials in contact with water being unsuitable for the purpose (see Clause 4.3.4.2).

(b) By cross connection between pipes conveying water supplied by the water undertaker with pipes conveying water from some other source.

(c) By stagnation particularly at high temperatures.

(d) As a result of backflow of water from water-fittings or water-using appliances into pipe work connected to mains or to other fittings and appliances (see Clause 4.3.4.3).

4.3.4.2 Prevention of Unsuitable Materials in Contact with Water

4.3.4.2.1 Unsuitable internal coating of pipes and cisterns

(1) Pipes, pipe fittings and storage cisterns made from or internally lined with lead shall not be used in any new installation or to replace any existing lead pipe or lead-lined cistern.

(2) No pipe, fitting or storage cistern shall be lined or coated internally with coal tar or with any material which will affect the quality of potable water.

4.3.4.2.2 Pipe lying in contaminated areas

(1) No pipe or fitting shall be laid in, on or though foul soil, refuse, sewer, cesspool or refuse chute or any manhole connected with them or any substance that might have an adverse effect on water quality unless the pipe is:

(a) Laid though a watertight, corrosion-resistance conduit of sufficient length and strength to afford adequate protection to the pipes, or

(b) Fixed not less than 600.0mm above the surface of the ground likely to the contaminated.

(2) No plastic pipe shall be laid where oil or petrol leakage or spillage should be expected to occur (unless suitable measures are taken to prevent contact of any oil or petrol with the plastic pipes) or where possible migration of petroleum materials and phenols from contaminated soils might occur.

4.3.4.3 Backflow Prevention

4.3.4.3.1 General

(1) Positive measures shall be taken to prevent:

(a) The ingress of contaminated water to any part of a water installation,

(b) The backflow of water from the installation to the supply mains; and

(c) Pumping on supply pipes (without the permission of the water supplier) which may cause backflow in adjacent pipes as shown in Figure 4.1.

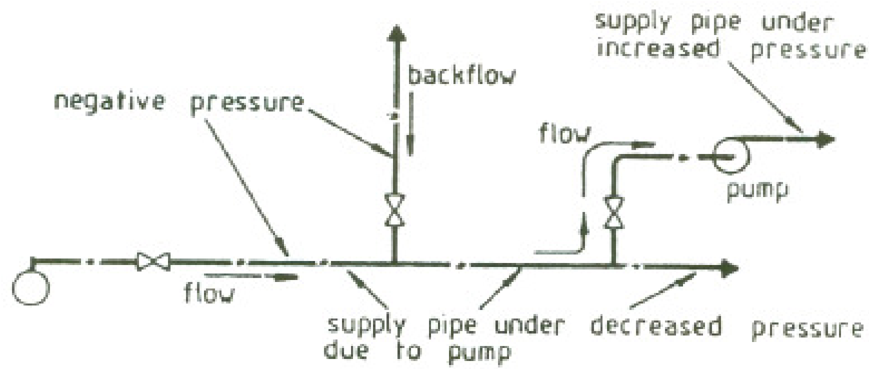


Figure 4-1 Backflow caused by pump installation

4.3.4.3.2 Draw-off taps

(1) Every draw-off tap or similar fitting installed to discharge water into a sink, was basin, bath or similar appliance shall be installed so that the vertical distance between the point of discharge of the fitting and the spill-over level of the receiving appliance shall not be less than that indicated in Table 4.3 for the size of the fittings concerned.

(2) Where it is not possible to provide a minimum air gap, the water outlet shall be protected with approved method of backflow prevention satisfactory to the Building Official.

4.3.4.3.3 Backflow protection for bidets

(1) Every bidet connected to a supply pipe shall be:

(a) Of the over-rim water fed type, and

(b) Installed and arranged so that the vertical distance between each point of discharge of water and the spill-over level of the bidet shall not be less than that indicated in Table 4.3 for the size of the water inlet fitting concerned.

4.3.4.3.4 Pipes conveying water to cisterns

(1) Every supply pipe conveying water to a cistern (whether or not fitted to a float-operated valve) shall be provided with air gaps (see Table 4.3) above the spill-over level of the cistern if:

(a) the cistern receives or contains any substance harmful to health, or

(b) the cistern is a flushing cistern or is holding water for non-domestic purposes.

(2) Paragraph (1b) above shall not apply to a supply pipe conveying water to a cistern:

(a) holding water supplied for domestic purposes and complying with Clause 4.4 for which no protection is required;

(b) fitted with a float-operated value of a reducing flow type which will prevent back siphonage through it if a vacuum occurs in the feed pipe.

Table 4-3 Minimum air gap [mm]

Diameter of the effective opening of water service (mm)	**Minimum air gap (mm)**
≤ 9	20
> 9 ≤ 12	25
> 12 ≤ 20	40
> 20 ≤ 25	50
> 25	2 x effective opening

4.3.4.4 Prevention of Contamination of Water by Cross Connection

(1) No supply pipe or cistern used for conveying or receiving water supplied by a public water supplier shall be connected so that it can receive or convey water for any non-domestic purpose or water that is not supplied by a public water supplier.

4.3.5 Water Supply Daily Requirements for Buildings

4.3.5.1 Water Supply for Residences

(1) Consumption of residential buildings depends on type of delivery of water to the end consumer and the living standard of the community. Table 4.4 shows the residential water requirements.

Table 4-4 Residential water requirements

Type of building occupancy	Consumption per head per day [l]
a) Dwellings with house connections*	
i) Low consumption	80-120
ii) Medium Consumption	120 – 200
iii) High consumption	200 - 300
(b) Dwellings with yard connection	40 – 60
(c) Public fountain (standard pipes)	15-20

*

i. Low consumption is dwelling unit with only one wet corner, fitted with shower, Hand wash basin, WC, traditional kitchen without kitchen sink, but with manual Laundry trough.

ii. Medium consumption is dwelling unit with two wet corners, fitted with shower, Bath tub, Hand wash basin, WC, kitchen sink and laundry sink or machine.

iii. High consumption is dwelling unit with more than two wet corners, fitted with all mentioned in (ii) above and sauna facilities and others.

4.3.5.2 Water Supply for Buildings Other than Residences

(1) Minimum requirements for water supply for buildings other than residences shall be in accordance with Table 4.5.

Table 4-5 Water requirements for buildings other than residences

Type of building occupancy	Consumption per head per day [l]
(a) Factories with bathroom	
(i) with canteen	50
(ii) without canteen	40
(b) Factories without bathroom	
(i) with canteen	35
(ii) without canteen	25
(c) Hospitals (per bed)	
i) Number of beds not exceeding 100	150-250
ii) Number of beds exceeding 100	250 – 350
d) Nursing homes and medical quarters	135
(e) Hostels (without canteen service)	100
f) Dormitories with canteen service	135
(f) Hotels (per bed)	
i) Up to 4 star	200
ii) 5 stars and above	350
(g) Offices	35
(h) Restaurants (per seat)	75
(i) Bars (per seat)	50
(j) Cinemas and theatres (per seat)	15
(k) Schools	
(i) Day Schools	25
(ii) Boarding schools (including canteen)	135

4.3.5.3 Water Supply Requirements of Traffic Terminal Stations

Minimum requirements for water supply for traffic terminal stations shall be in accordance with Table 4.6.

Table 4-6 Water Supply Requirements of Traffic Terminal Stations

No.	Nature of Station/Terminal	Without Bathing Facilities (liters/capita)
1	Intermediate stations (excluding meal and Express stops)	25
2	Junction stations and intermediate stations where meal or express Stoppage is provided	45
3	Terminal stations	45
4	International and Domestic airports	70

Source: National Building Code of India (2005), page 19

4.3.5.4 Water Supply for Fire Fighting Purposes (Refer Fire Code – EBCS-13)

Due reference should be made to the fire code (EBCS-13) to estimate the water supply requirements for firefighting purpose as a function of building type and material and the fire extinguishing system.

4.4 Storage Cisterns

4.4.1 General

(1) In a building, provisions shall be made for storage of water:
  a) to provide against interruptions of the supply caused by repairs to mains, etc;
  b) to reduce the maximum rate of demand on the mains;
  c) to tide over periods of intermittent supply; and
  d) to maintain a storage for the fire fighting requirement of the building

(2) Every storage tank shall be easily accessible and placed in such a position as to enable thorough inspection and cleaning to be carried out. In large storage tanks, the outlet shall be at the end opposite the inlet to avoid stagnation of the water.

(3) Storage cisterns and their lids for domestic water supply purposes should not impart taste, color, odor or toxicity to the water, nor promote microbial growth.

(4) The water may be stored either in overhead tanks (OHT) and/or underground tanks (UGT) and storage cisterns above 5000 liter capacity shall be divided into two or more compartments or tanks to avoid interruption of the water supply when carrying out

cleaning, inspection or maintenance of the cistern without interfering with the water supply system.

(5) Any cistern shall be:

(a) a watertight vessel having a tight fitting;
(b) where necessary, lined or coated with a material suitable for use in contact with potable water and must not deform unduly in use;
(c) where necessary, insulated against heat;
(d) with access for inspection and maintenance;
(e) supported on a firm level base capable of withstanding the weight of the cistern when filled with water to the rim;
(f) provided with inlet (including float-operated valve or other approved type control system), outlet, overflow and drain pipes.

4.4.2 Underground Cisterns

(1) No cistern shall be buried or sunk in the ground unless special measures are taken to avoid leakage and protect the cistern from ingress of contaminants.

(2) Unless used only for non-potable water, every underground cistern shall be protected from ingress of surface water or ground water and such cisterns shall be well ventilated and protected from ingress of animals and insects and accessible for maintenance.

(3) The underground tanks should not be located in low lying areas or near any public or private sewer, septic tank, leaching pool or soakage pit to prevent any contamination. For tanks with at least one side exposed to a basement, it is safer to discharge the overflow into the basement level provided that the basement has proper drainage system.
(4) The tank structure shall also be designed to carry the load due to fire tender movement.
(5) There shall be no common wall between the tanks storing safe water and tanks storing water from unsafe sources.

4.4.3 Elevated and Ground Cisterns

(1) Cisterns mounted within the premises of a building shall be well ventilated and protected from ingress of birds, animals and insects and provided with access to the interior of the cistern for maintenance.

(2) Ventilation openings shall be screened by corrosion-resistant mesh.

(3) There should be no common wall between the tanks storing safe water and tanks storing water from unsafe sources.

(4) In tall buildings, the top of the tank shall be provided with the safe ladder or staircase. The top slab shall be provided with railing or a parapet wall.

4.4.4 Cistern Accessories

Each tank shall be provided with the followings

(1) Manholes – Provide adequate number of manholes for access and repair. The manholes shall made of corrosion resistant material (For example, cast iron, reinforced cement concrete, steel fiber reinforced concrete, galvanized steel, high density polyethylene, fiber glass reinforced plastic or such other materials acceptable to the Authority). Manholes shall be provided with locking arrangement to avoid misuse and tampering.

(2) Ladders — Tanks higher than 1m deep shall be provided with internal corrosion steps or ladders according to the depth to enable a person to reach the bottom of the tank.

(3) Overflow Pipe — Each tank shall be provided with an overflow pipe made of rigid, corrosion resistance material, preferably terminating above the ground level to act as a 'Warning Pipe' to indicate overflow conditions. The size of the overflow pipe shall be adequate to accept the flow. The overflow pipe size shall be at least one size higher than the inlet pipe. When the inlet pipe diameter is large, two or more overflow pipes of equivalent cross section may be provided. The overflow of the tank should be well above (preferably 600 mm) the external surface level and terminate as a warning pipe with a mosquito proof grating. Care must be taken to prevent backflow of local surface water into the tank in case of local flooding. Otherwise the overflow must be terminated in a safer manner as per the site conditions. For tanks with at least one side exposed to a basement, it is safer to discharge the overflow into the basement level provided that the basement has proper drainage system.

(4) Vent Pipes — Tanks shall be provided with vent pipes to prevent development of pressure in the tank which might result in NO FLOW condition or inward collapse of the tank.

(5) Scour/Drain Pipe — Each tank shall be provided with a scour pipe with an accessible drain valve located at their lowest point with the floor of the cisterns laid to a slight fall to the drains for emptying the tank.

(6) Connection of Overflow and Scour/Drain Pipe —Under no circumstances tank overflow and scour pipe shall be connected to any drain, gully trap or manhole to prevent back flow and contamination of the water. All such connections shall be discharged over a grating with an air gap of minimum 50 mm. All overflow and vent pipes shall be provided with a mosquito proof corrosion resistant grating to prevent ingress of mosquito, vermin and other insects.

(7) The top slab of the tank must be suitable sloped away from its, centre for proper drainage of the rainwater.

(8) Tanks on terraces and above ground shall be supported by appropriate structural members so as to transfer the load of the tank and the water directly on the structural members of the building.

(9) Outlet pipes : Outlet pipes shall conform to the following:

(a) The heights of connection to outlet pipes (heights up to the invert of outlet pipes) above the bottom of a gravity cistern of capacity 5000.0 liter and above shall not be less than 80.0mm.

(b) Such heights shall not be less than 50.0mm for cisterns of capacity less than 5000.0 liter.

(c) Outlets should be provided with suitable strainers of corrosion resistance materials.

(d) For pump-suction cisterns, the height of connection of suction pipes shall comply with the provisions of clause 4.4.6.

(e) For jointing steel pipe to a storage tank, the end of the pipe shall be screwed, passed through a hole in the tank and secured by back nuts, both inside and outside. For jointing copper pipe to steel or copper tank, a connector of non-ferrous material shall be used. The connector shall have a shoulder to bear on the outside of the tank and shall be secured by a back nut inside.

(10) Inlet Pipes - Inlet pipes and float-operated control valves shall confirm to the following:

(a) Except for interconnected cisterns arranged to store water at the same level, every pipe supplying water to a storage cistern shall be fitted with a float-operated valve or some other equally effective and approved device to control the inflow of water and maintain it at the required level.

(b) The water level shall be at least 50.0 mm below the lowest point of the lowest overflow pipe connection.

(c) The inlet control device shall be suitable for the particular application, bearing in mind the supply pressure and the temperature of the water in the cistern.

(d) Every float-operated valve shall be securely fixed to the storage cistern it supplies and, where necessary, braced to prevent the thrust of the float causing the valve to move and so effect the water level.

4.4.5 Cistern Capacity Design

(1) In designing the storage capacity, consideration shall be taken of the pattern of water use in the premises concerned, hours of supply to fill up the storage tanks, likely frequency and duration of breakdown in supply from the water supplier's mains and consequences of exhausting storage.

General guidelines for calculation of the minimum recommended capacity of storage tanks shall be as follows:

(a) In case only elevated water tank is provided, it may be taken as 33 to 50 percent of one day's requirement;

(b) In case only underground water tanks is provided, it may be taken as 50 to150 percent of one day's requirement; and

(c) In case combined storage is provided, it may be taken as 67 percent underground tank and 33 percent elevated water tank of one day's requirement.

4.4.6 Effective Storage Capacity of Pump Suction Cistern

(1) (a) The effective storage capacity shall be taken as the measurement between the normal water level in the cistern or tank and the low water level designated 'X' as shown in Figure 4.2.

(b) Low water level 'X' is taken to be the lowest level before a vortex is created causing the pump to draw air.

(c) The effective depth is then multiplied by the average surface area of the storage to obtain the effective capacity.

(2) Where the suction pipe is taken from the side of the storage, as shown in Figure 4.2 (b) and (e), the clearance between the base of the storage and the lowest part of the pump-suction pipe shall not be less than the dimension B as given in the figure.

(3) (a) Where a suction pipe draws from a sump in the base of a storage, the sump length shall be not less than the dimensions indicated in Figure 4.2 (d), (e) and (f).

(b) In addition, the sump width shall be not less than 3.6D where D is the nominal diameter of the suction pipe.

(c) The point of entry shall be located centrally across the width of the sump.

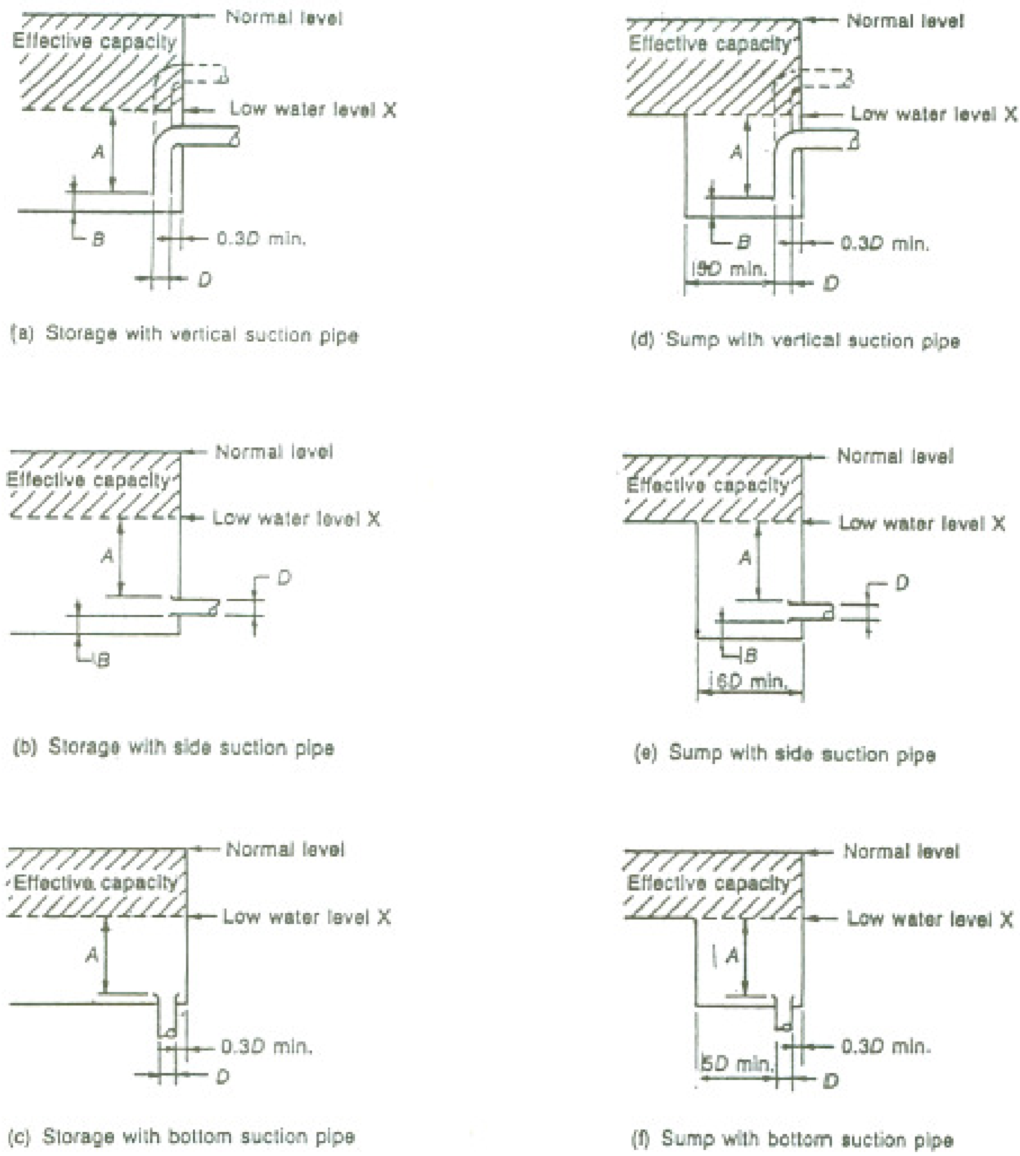
(4) When an approved vertex inhibitor is installed, the following variation to the dimensions given in (3) above shall apply:

(a) Dimension A in Figure 4.2 may be disregarded and low water level X may be taken as the level at which vortex action commences.

(b) Dimension B in Figure 4.2 may be taken from the base of the tank to the level at which a vertex action commences in Figure 4.2(a).

Notes: (i) Vortex inhibitors are not suitable for use in sump.
(ii) Figure 4.2(b) is unlikely to be appropriate to arrangement employing a vortex inhibitor.

(5) Where arrangements depicted in Figure 4.2 are not applicable, different intake design may be accepted in agreement with Building Official.



millimetres

Nominal diameter of suction pipe	Dimension A	Dimension B
65	250	80
80	310	80
100	370	100
150	500	100
200	620	150
250	750	150

Figure 4-2 Vertical cross-section showing effective capacity of storage

4.5 Pipes and Isolating Valves

4.5.1 Pipes

(1) For water supply pipes and fittings refer to clause 4.2 and any approved standards.

4.5.2 Isolating Valves

(1) The flow from any water main to any water service pipe, and within the water service pipes, shall be controlled by means of isolating valves (stop valves and service valves), the location as specified in Table 4.7.

(2) Isolating valves shall be installed so that they are accessible.

4.6 Pumps and Equipment

4.6.1 General

(1) Electrically driven centrifugal pumping plant are normally used and pumps shall be duplicated and use alternatively

(2) Where prudent, provision shall be made for the pumps to be supplied by an alternative power supply in the event of mains failure.

(3) Pumps may be of either a horizontal or vertical type, directly coupled to their electric motors.

(4) Pumps shall be sized so that each pump is capable of overcoming the static lift plus the friction losses in the pipe work and valves.

(5) Where pumps are connected directly to the service pipe, full allowance shall be made when calculating the required pump head for the pressure already in the service pipe, since the pump head is added to this and does not cancel out an existing pressure.

(6)The fittings of motors with sleeve-type super-silent bearings shall be considered in order to achieve quite running

(7) (a) Automatic control of a pumping plant is essential and pressure switches, level switches or high-level and low-level electrodes will give reliable control. Other methods of control, both mechanical and electrical, can be adopted.

(b) Pumping equipment shall be controlled via a pump selector switch and an ON/OFF/AUTO Control.

(c) Pumps shall be capable of being stopped or started manually.

(d) Pumps shall be controlled to limit the number of starts per hour to within the capacity of the pump.

Table 4-7 Isolating valves for water services

Location	Type of valve
(a) General	
(i) At the water main tapping	Stop valve
(ii) At the meter	stop valve
(iii) At each flushing cistern	service valve
(iv) At each appliance	service valve
(v) At each pressure limiting valve	stop valve
(vi) At each pumping apparatus	stop valve
(vii) At each storage tank (inlet)	stop valve
(viii) At each storage tank outlet	stop valve
(b) Multiple buildings/multi-story	
(i) At each branch serving individual building	stop valve
(ii) At each branch serving each floor in building of 2 or more storeys	stop valve
(iii) At each group of fixtures	stop valve

Notes: (i) Stop valve is a valve which can be operated to stop the flow in a pipeline.
(ii) Service valve is a valve which can be operated to stop the flow into an appliance or fixture.

(8) (a) Most small air compressor used for charging pneumatic pressure vessels or pressure tanks are of the reciprocating type, shall be either air or water cooled.

(b) The air to be compressed shall be drawn from a clean cool source and should be protected from contamination.

4.6.2 Pump Room

(1) A pump room shall be of adequate size to accommodate all the plant and also to provide adequate space for maintenance and replacement of parts.

(2) A pump room shall be dry, ventilated and protected from flooding.

(3) Entry of birds and small animals shall be prevented and access should be restricted to authorized persons

4.6.3 Installation of Pumps

(1) Pumps shall:

(a) be installed on a base to suit satisfactory operation of the pump;
(b) have vibration eliminators at the base of the pump, in the suction side and the delivery side of the pump so as to minimize the transmission of noise into the building structure and along the piping system and the prevent undue stress being placed on the pump;
(c) have isolation valves on the delivery side and the suction side of the pump;
(d) have a non-return valve on the delivery side of the pump before the isolation valve;
(e) have pressure gauges on the inlet and outlet of the pump; and
(f) have unions or flanges to enable the removal of the pump;

Note: where a standby pump arrangement is installed, the pumps shall be electrically coupled in such a manner that each pump can operate individually but can be changed over for standby or alternative duty.

4.7 Water Meters

4.7.1 Location of Water Meters

(1) Water meters shall be located as follows:

(a) Within the property; in an accessible position.
(b) Proximity to isolating valve; positioned immediately downstream of the meter isolating valve.
(c) Proximity to street-alignment; as near as practicable to the street alignment.
(d) In other locations; as required by the relevant regulatory authority.

4.7.2 Installation of Water Meters

(1) Water meters shall be installed:

(a) so as to be accessible for reading, maintenance or removal; and
(b) in horizontal position unless designed to operate otherwise.

(2) Water meters to be installed inside buildings shall be fixed with the distance not more than 1.5m above floor level and readily visible for reading.

(3) Water meters to be installed below ground level shall be located in a chamber that has a cover removable by one person and provided with a base that enable drainage. Where liable to vehicular damage, water meters shall be protected.

(4) Water meters DN 50 mm or larger in size shall be supported independently of the pipe work.

4.8 Design of Water Distribution System

4.8.1 General Requirements

1) The sizes of the pipes and fittings used in a water service shall be such that will provide an adequate rate of delivery of water without recourse to wasteful over sizing.

2) The installation shall be sized so that design flow rates given in Table 4.8 shall be available at each outlet when only that outlet is open and at all outlets for most of the time. The pipes and fittings shall also be sized so that the water velocity in any pipe does not exceed those given in Table 4.11.

3) (a) In small, simple installations such as those in small dwellings, it is often possible to size pipes on the basis of experience and convention.

   (b) In all other cases, the pipe sizes shall be calculated in accordance with good engineering practice.

4) The amount of either hot or cold water used in any building is variable, depending on the type of occupancy and time of day. Optimum pipe sizes shall be designed to meet peak demand.
5) All premises intended for human habitation, occupancy, or use shall be provided with supply of potable water. This water supply shall not be contaminated with unsafe water sources, nor shall it be subject to the hazards backflow.
6) Plumbing fixtures, devices and appurtenances shall be provided with water in sufficient volume and at pressures adequate to enable them to function properly and without undue noise under normal conditions of use.
7) The system shall be designed, installed and adjusted to use the optimum quantity of water consistent with proper performance and cleaning.
8) The system shall be designed and installed with safety devices to safeguard against dangers from contamination, explosion, overheating, etc.

4.8.2 Rate of Flow

1) Pipes and fittings shall be sized so that the flow rates for individual draw-offs are equal to the design flow rates shown in table 4.8 and during simultaneous discharges the minimum flow rates shall be maintained on each tap.

Table 4-8 Design flow rates and loading units

Outlet fitting	Design flow rate (l/s)	Minimum flow rate l/s	Loading units
WC flushing cistern single or dual flush – to fill in 2 minutes	0.13	0.05	2
WC trough cistern	0.15 per WC	0.10	2
Wash basin tap size ½ DN 15	0.15 per tap	0.10	1.5 to 3
	0.05 per tap	0.03	–
Spray tap or spray mixer	0.20 per tap	0.10	1
Bidet	0.30	0.20	10
Bath tap, nominal size ¾ DN 20	0.60	0.40	22
	0.20 hot or cold	0.10	3
	0.20	0.10	3
Bath tap, nominal size 1 – DN 25			
Shower head (will vary with type of head)	0.30	0.20	5
Sink tap, nominal size ½ DN 15	0.60	0.40	–
	0.20 hot or cold	0.15	
	0.15	0.10	3
Sink tap, nominal size 3/4 DN 20	0.004 per position served	0.002	–

Source: BS 6700

Notes:

1. Flushing troughs are advisable where likely use of WCs is more than once per minute.
2. Mixer fittings use less water than separate taps, but this can be disregarded in sizing.
3. Flow rates to shower mixers vary according to type fitted. Manufacturers should be consulted.
4. Manufacturers should be consulted for flow rates to washing machines and dishwashers for other than a single dwelling.
5. For cistern fed urinals demand is very low and can usually be ignored. Alternatively, use the continuous flow.

(2) Loading units should not be used for outlet fittings having high peak demands, e.g. those in industrial installations. In these cases use the continuous flow.

(3) BS 6700 does not give loading units for sink tap DN 20 or pressure flushing valve for WCs or urinals.

4.8.3 Pipe Sizing

Pipe sizes shall ensure adequate flow rates at appliances and avoid problems that lead to (see Figure 4.3):

(1) Over-sizing that shall cause
   a) additional and unnecessary installation costs;
   b) delays in obtaining hot water at outlets;
   c) increased heat losses from hot water distributing pipes.

(2) Under-sizing that shall cause:
a) inadequate delivery from outlets and possibly no delivery at some outlets during simultaneous use;
b) some variation in temperature and pressure at outlets, especially showers and other mixers;
c) some increase in noise levels.

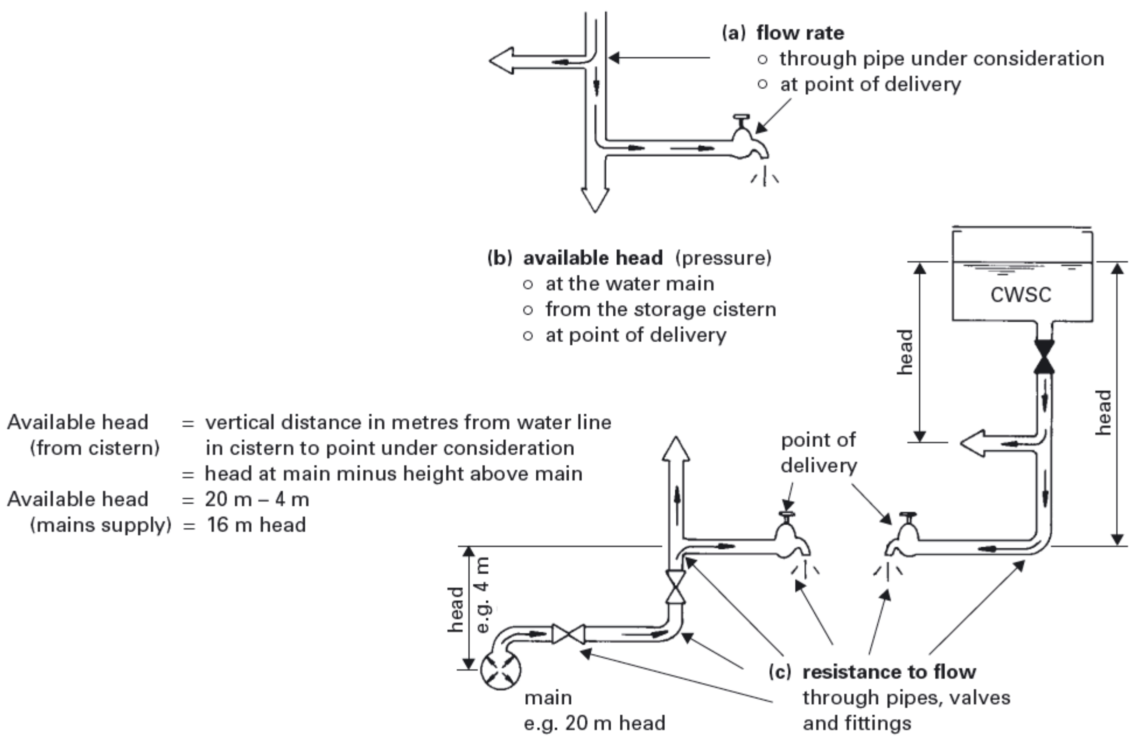


Figure 4-3 Pipe sizing considerations (Source: BS 6700)

(3) In smaller, straightforward installations such as single dwellings, pipes are often sized on the basis of experience and convention.

(4) In larger and more complex buildings, or with supply pipes that are very long, it is necessary to use a recognized method of calculation such as that shown in sections 4.8.3.1 and 4.8.3.2.

4.8.3.1 Sizing procedure for supply pipes

The procedure below is followed by an explanation of each step with appropriate examples.

(1) Assume a pipe diameter.
(2) Determine the flow rate:
  (a) by using loading units;
  (b) for continuous flows;
  (c) obtain the design flow rate by adding (a) and (b).
(3) Determine the effective pipe length:
  (d) work out the measured pipe length;
  (e) work out the equivalent pipe length for fittings;
  (f) work out the equivalent pipe length for draw-offs;
  (g) obtain the effective pipe length by adding (d), (e) and (f).
(4) Calculate the permissible loss of head:
  (h) determine the available head:
  (i) determine the head loss per metre run through pipes;
  (j) determine the head loss through fittings;
  (k) calculate the permissible head loss.
(5) Determine the pipe diameter:
  (l) decide whether the assumed pipe size will give the design flow rate in (c) without exceeding the permissible head loss in (k).

Explanation of the procedure

Assume a pipe diameter (1)

In pipe sizing it is usual to make an assumption of the expected pipe size and then prove whether or not the assumed size will carry the required flow.

Determine the flow rate (2)

In most buildings it is unlikely that all the appliances installed will be used simultaneously. As the number of outlets increases the likelihood of them all being used at the same time decreases. Therefore it is economic sense to design the system for likely peak flows based on probability theory using loading units, rather than using the possible maximum flow rate.

(a) Loading units. A loading unit is a factor or number given to an appliance which relates the flow rate at its terminal fitting to the length of time in use and the frequency of use for a particular type and use of building (probable usage). Loading units for various appliances are given in table 4.8. By multiplying the number of each type of appliance by its loading unit and adding the results, a figure for the total loading units can be obtained. This is converted to a design flow rate using Figure 4.4. An example using loading units is given in Figure 4.5.

(b) Continuous flows. For some appliances, such as automatic flushing cisterns, the flow rate must be considered as a continuous flow instead of applying probability theory and using loading units. For such appliances the full design flow rate for the outlet fitting must be used, as given in Table 4.8. However, in the example shown in Figure 4.5, the continuous flow for the two urinals of 0.008 l/s (from table 4.8) is negligible and can be ignored for design purposes.

(c) Design flow rate. The design flow rate for a pipe is the sum of the flow rate determined from loading units (a) and the continuous flows (b).

Determine the effective pipe length (3)

(d) Find the measured pipe length. Figure 4.6 is an example showing how the measured pipe length is found. Therefore, from figure 4.4, the required flow rate for the system is 0.7 l/s.

(e, f) Find the equivalent pipe lengths for fittings and draw-offs. For convenience the frictional resistances to flow through fittings are expressed in terms of pipe lengths having the same resistance to flow as the fitting. Hence the term 'equivalent pipe length' (see table 4.9). For example, a 20 mm elbow offers the same resistance to flow as a 20 mm pipe 0.8 m long. Figure 4.7 shows the equivalent pipe lengths for the fittings in the example in Figure 4.6.

Table 4-9 Equivalent pipe length (copper, galvanized steel and plastics)

Bore of pipe	Equivalent pipe length			
	Elbow	Tee	Stopvalve	Check valve
mm	m	m	m	m
12	0.5	0.6	4.0	2.5
20	0.8	1.0	7.0	4.3
25	1.0	1.5	10.0	5.6
32	1.4	2.0	13.0	6.0
40	1.7	2.5	16.0	7.9
50	2.3	3.5	22.0	11.5
65	3.0	4.5	–	–
73	3.4	5.8	34.0	–

Notes:
(1) For tees consider change of direction only. For gate valves losses are insignificant.
(2) For fittings not shown, consult manufacturers if significant head losses are expected.
(3) For galvanized steel pipes in a small installation, pipe sizing calculations may be based on the data in this table for equivalent nominal sizes of smooth bore pipes. For larger installations, data relating specifically to galvanized steel should be used. BS 6700 refers to suitable data in the *Plumbing Engineering Services Design Guide* published by the Institute of Plumbing.

(g) Effective pipe length. The effective pipe length is the sum of the measured pipe length (d) and the equivalent pipe lengths for fittings (e) and draw-offs (f).

Therefore, for the example shown in Figure 4.6 the effective pipe length would be:
Measured pipe length 4.75 m
Equivalent pipe lengths

elbows	2 × 0.8 = 1.6 m
tee	1 × 1.0 = 1.0 m
stopvalve	1 × 7.0 = 7.0 m
taps	2 × 3.7 = 7.4 m
check valves	2 × 4.3 = 8.6 m

Effective pipe length = 30.35 m

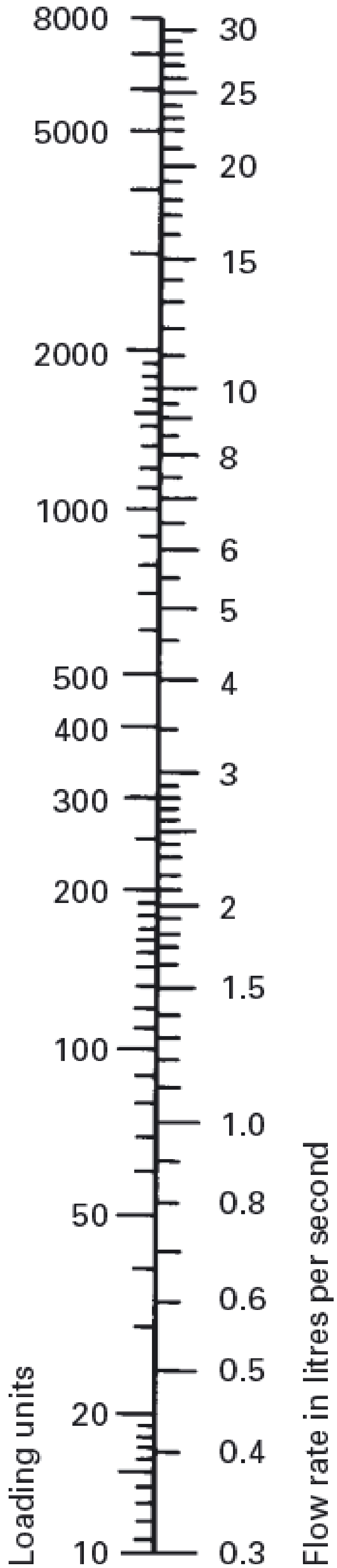
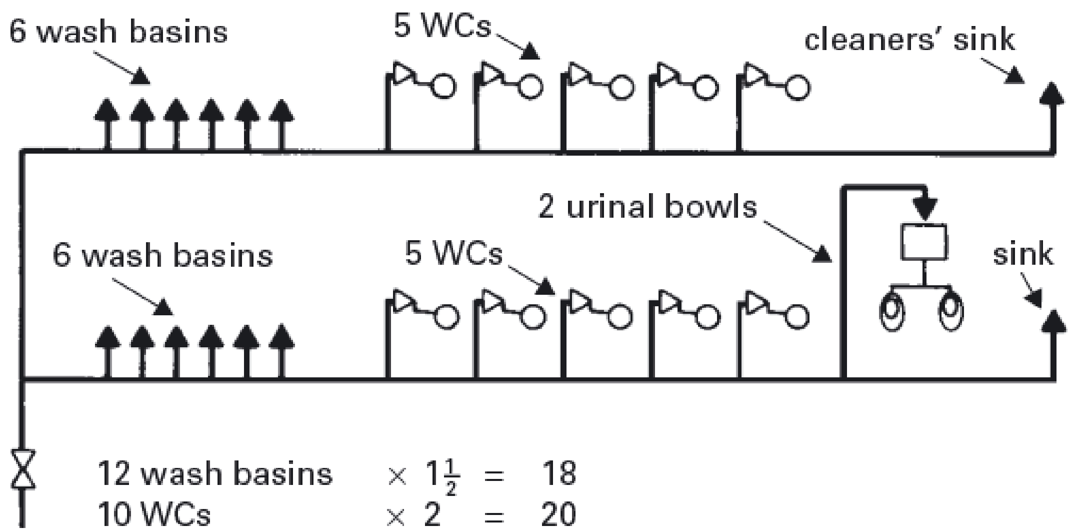
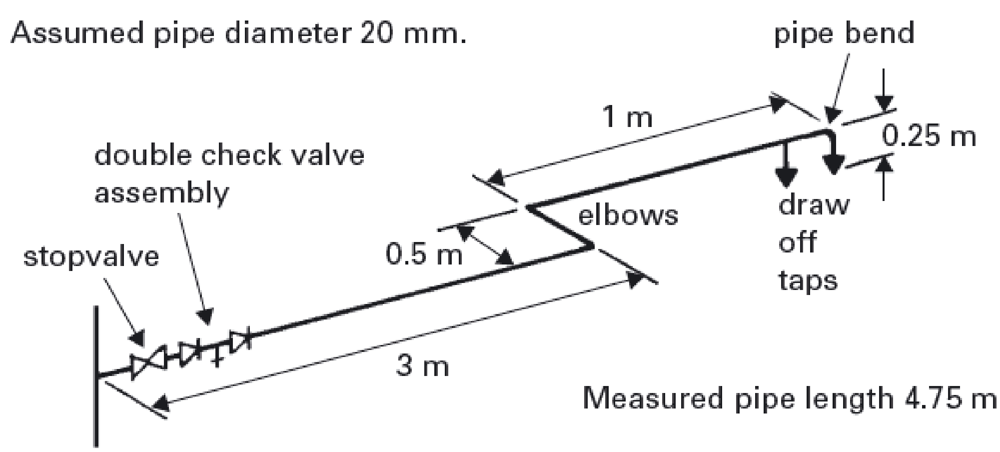


Figure 4-4 Conversion chart - loading unit to flow rate



12 wash basins	× 1½	=	18
10 WCs	× 2	=	20
2 urinal bowls	× —	=	—
2 cleaners' sinks	× 3	=	6
Total loading units			44

Figure 4-5 Example of use of loading units



Note There is no need to consider both branch pipes to taps.

Figure 4-6 Example of measured pipe length

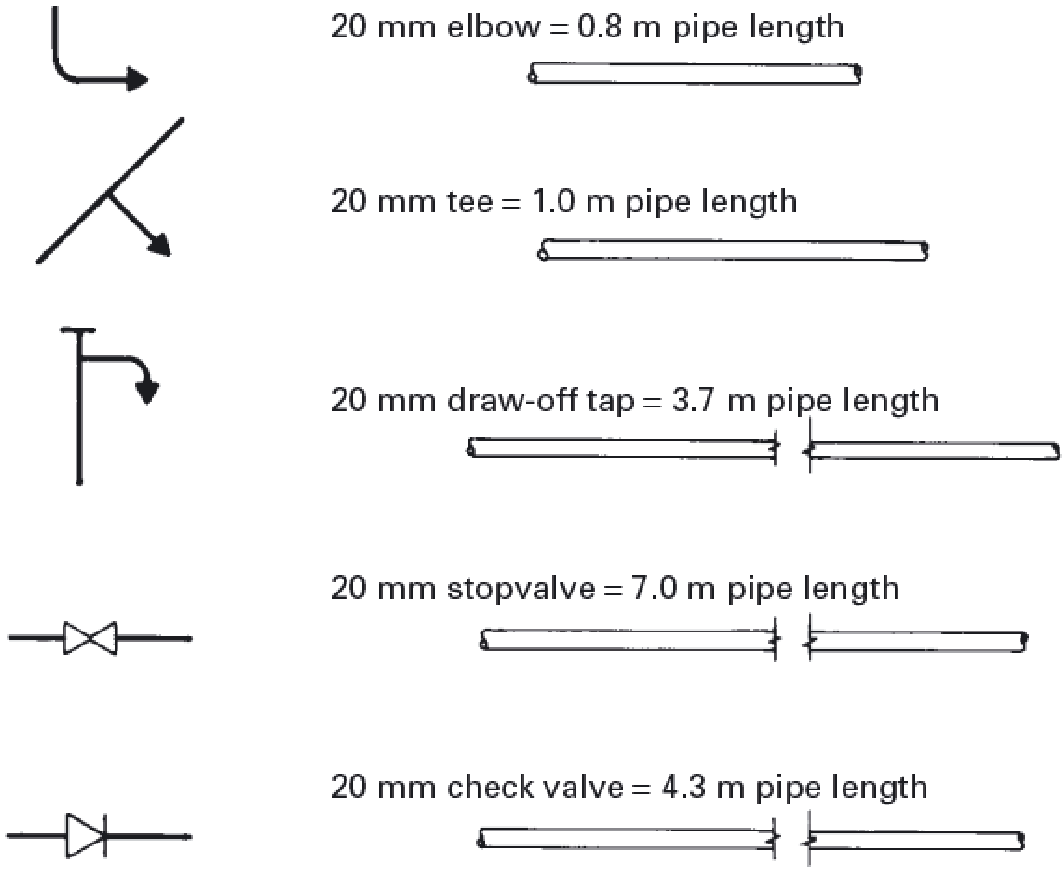


Figure 4-7 Examples of equivalent pipe length (using the example from Figure 4.6)

Permissible loss of head (pressure) (4)

Pressure can be expressed in the following ways.

(i) In Pascal, the Pascal (Pa) being the SI unit for pressure.

(ii) As force per unit area, N/m^2.

1 N/m2 =1 Pascal (Pa).

(iii) As a multiple of atmospheric pressure (bar).

Atmospheric pressure =100 kN/m^2 =100 kPa = 1 bar.

(iv) As meters head, that is, the height of the water column from the water level to the draw-off point.

1 m head =9.81 kN/m^2 =9.81 kPa = 98.1 mb.

In the sizing of pipes, any of these units can be used. However, meter head shall be used for giving a more visual indication of pressure that compares readily to the height and position of fittings and storage vessels in the building.

(h) Available head. This is the static head or pressure at the pipe or fitting under consideration, measured in meter head (see Figure 4.3).

(i) *Head loss through pipes.* The loss of head (pressure) through pipes due to frictional resistance to water flow is directly related to the length of the pipe run and the diameter of the pipe. Pipes of different materials will have different head losses, depending on the roughness of the bore of the pipe and on the water temperature. Copper, stainless steel and plastics pipes have smooth bores and only pipes of these materials are considered in this section.

(j) *Head loss through fittings.* In some cases it is preferable to subtract the likely resistances in fittings (particularly draw-offs) from the available head, rather than using equivalent pipe lengths. Table 4.10 gives typical head losses in taps for average flows compared with equivalent pipe lengths. Figures 4.8 and 4.9 provide a method for determining head losses through stop valves and float-operated valves respectively.

Note: Where meters are installed in a pipeline the loss of head through the meter shall be deducted from the available head.

Table 4-10 Typical head losses and equivalent pipe lengths for taps

Nominal size of tap	Flow rate l/s	Head loss m	Equivalent pipe length m
G $\frac{1}{2}$ – DN 15	0.15	0.5	3.7
G $\frac{1}{2}$ – DN 15	0.20	0.8	3.7
G $\frac{3}{4}$ – DN 20	0.30	0.8	11.8
G 1 – DN 25	0.60	1.5	22.0

Determine the pipe diameter (5)

In the example in Figure 4.6 a pipe size of 20 mm has been assumed. This pipe size must give the design flow rate without the permissible head loss being exceeded. If it does not, a fresh pipe size must be assumed and the procedure worked through again.

Figure 4.10 relates pipe size to flow rate, flow velocity and head loss. Knowing the assumed pipe size and the calculated design flow rate, the flow velocity and the head loss can be found from the figure as follows.

(1) Draw a line joining the assumed pipe size (20 mm) and the design flow rate (0.4 l/s).

(2) Continue this line across the velocity and head loss scales.

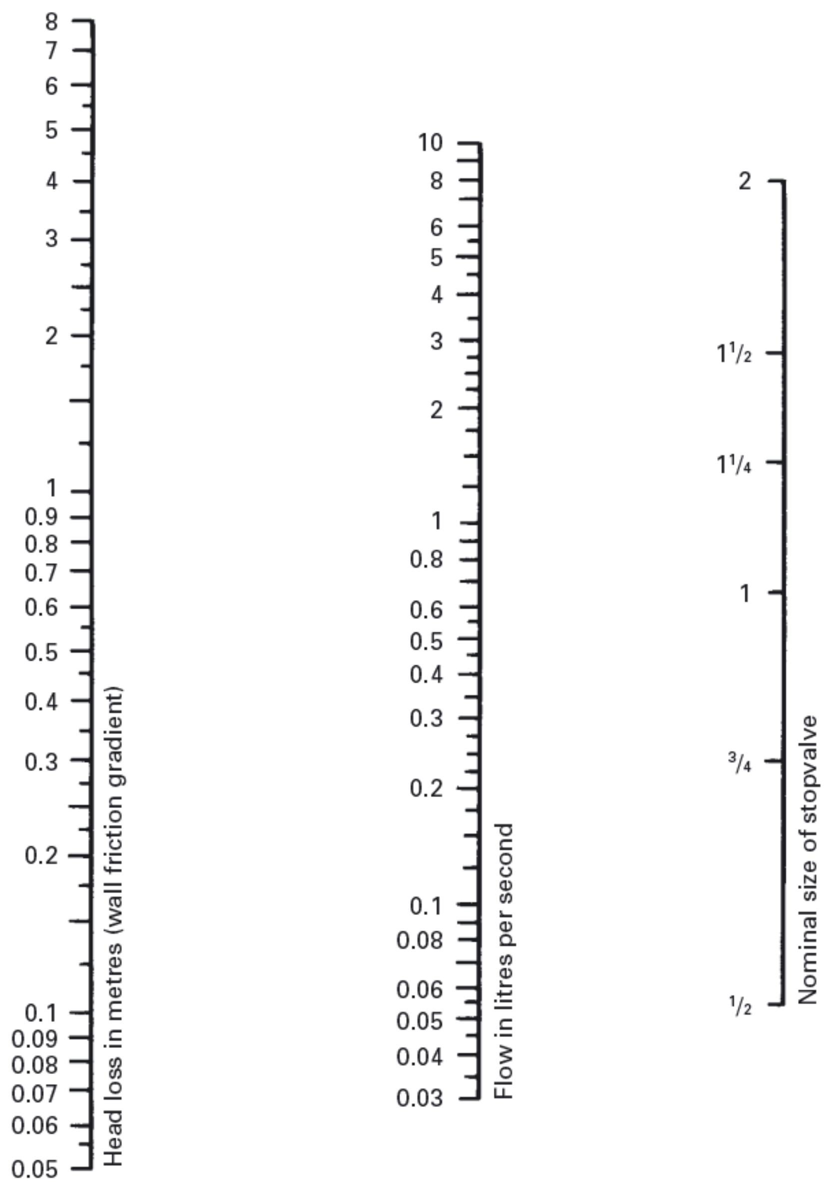
(3) Check that the loss of head (0.12 m/m run) does not exceed the calculated permissible head loss of 1.48 m/m run.

(4) Check that the flow velocity (1.4 m/s) is not too high by referring to 4.11.

Table 4-11 Maximum recommended flow velocities

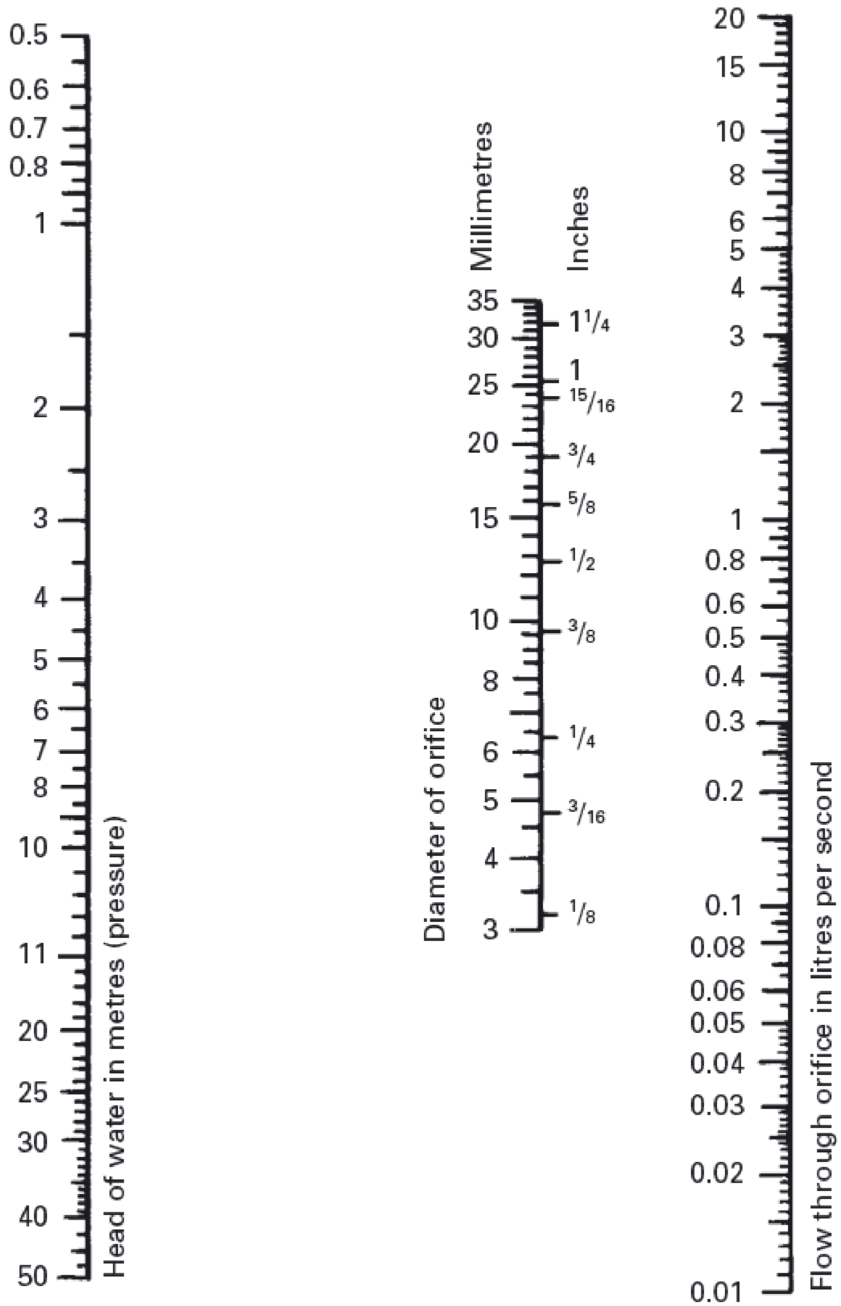
Water temperature °C	Flow velocity	
	Pipes readily accessible m/s	Pipes not readily accessible m/s
10	3.0	2.0
50	3.0	1.5
70	2.5	1.3
90	2.0	1.0

Note Flow velocities should be limited to reduce system noise.



Note Gate valves and spherical plug valves offer little or no resistance to flow provided they are fully open.

Figure 4-8 Head loss through stop valves



Based on $Q = AV0.75$

$V = \sqrt{2gH}$

where Q is flow (l/s)

A is cross sectional area of pipe (m^2)

V is velocity (m/s)

g is acceleration due to gravity (m/s^2)

H is head of water (m)

Figure 4-9 Head loss through float operated valves

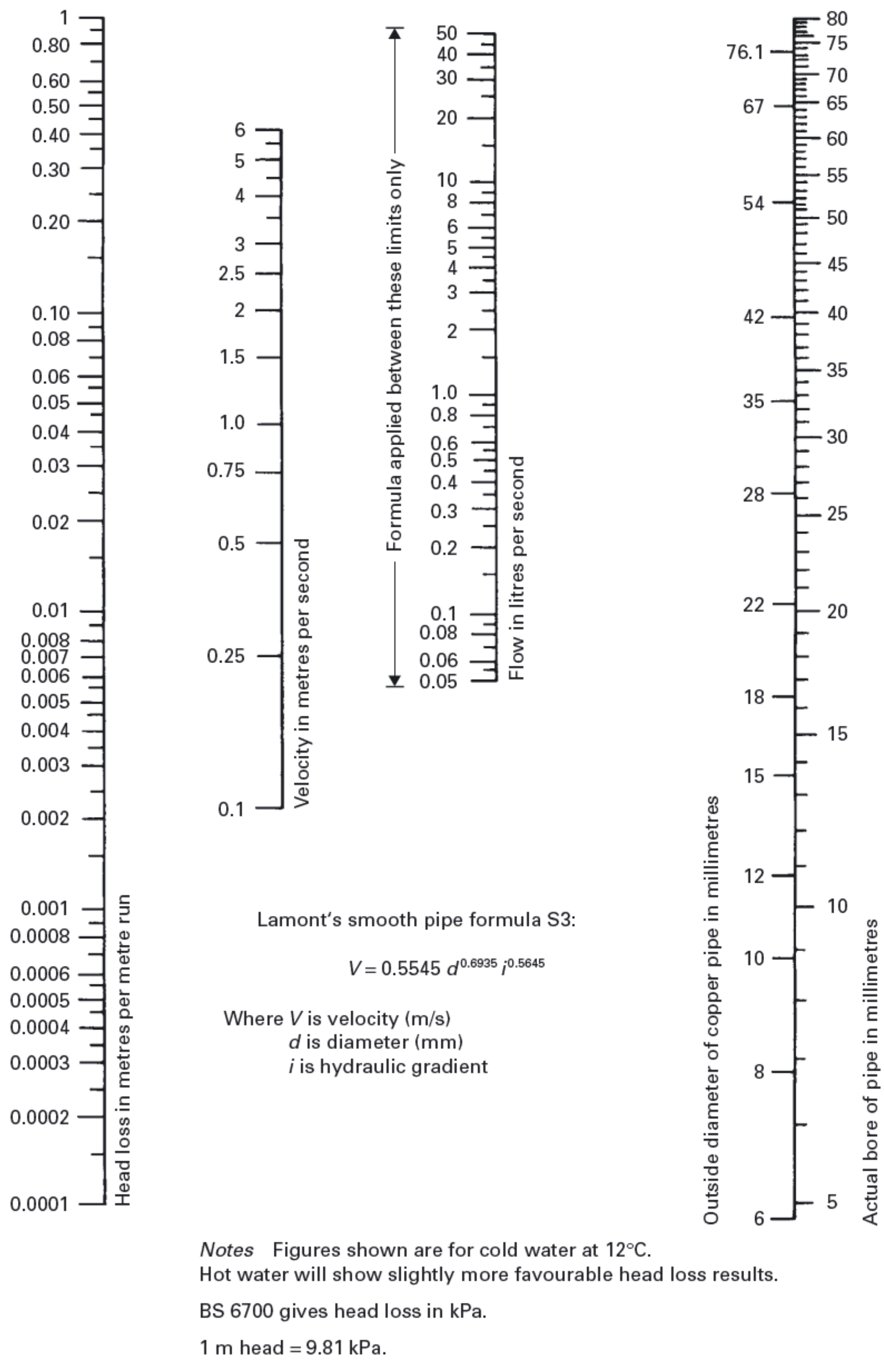


Figure 4-10 Determination of pipe diameter

4.8.3.2 Tabular method of pipe sizing

The tabular method uses a work sheet which can be completed as each of the steps is followed in the pipe sizing procedure. An example of the method follows with some explanation of each step.

Explanation of the tabular method

Pipe work diagram

(1) Make a diagram of the pipeline or system to be considered (see Figure 4.11).
(2) Number the pipes beginning at the point of least head, numbering the main pipe run first, then the branch pipes.
(3) Make a table to show the loading units and flow rates for each stage of the main run. Calculate and enter loading units and flow rates; see Figure 4.11.

Calculate flow demand

(1) Calculate maximum demand (see Figure 4.11):

a) add up loading units for each stage (each floor level);
b) convert loading units to flow rates;
c) add up flow rates for each stage.

(2) Calculate probable demand (see Figure 4.11):

a) add up loading units for all stages;
b) convert total loading units to flow rate.

(3) Calculate percentage demand (number of stages for which frictional resistances need be allowed). See Figure 4.13.

Work through the calculation sheet

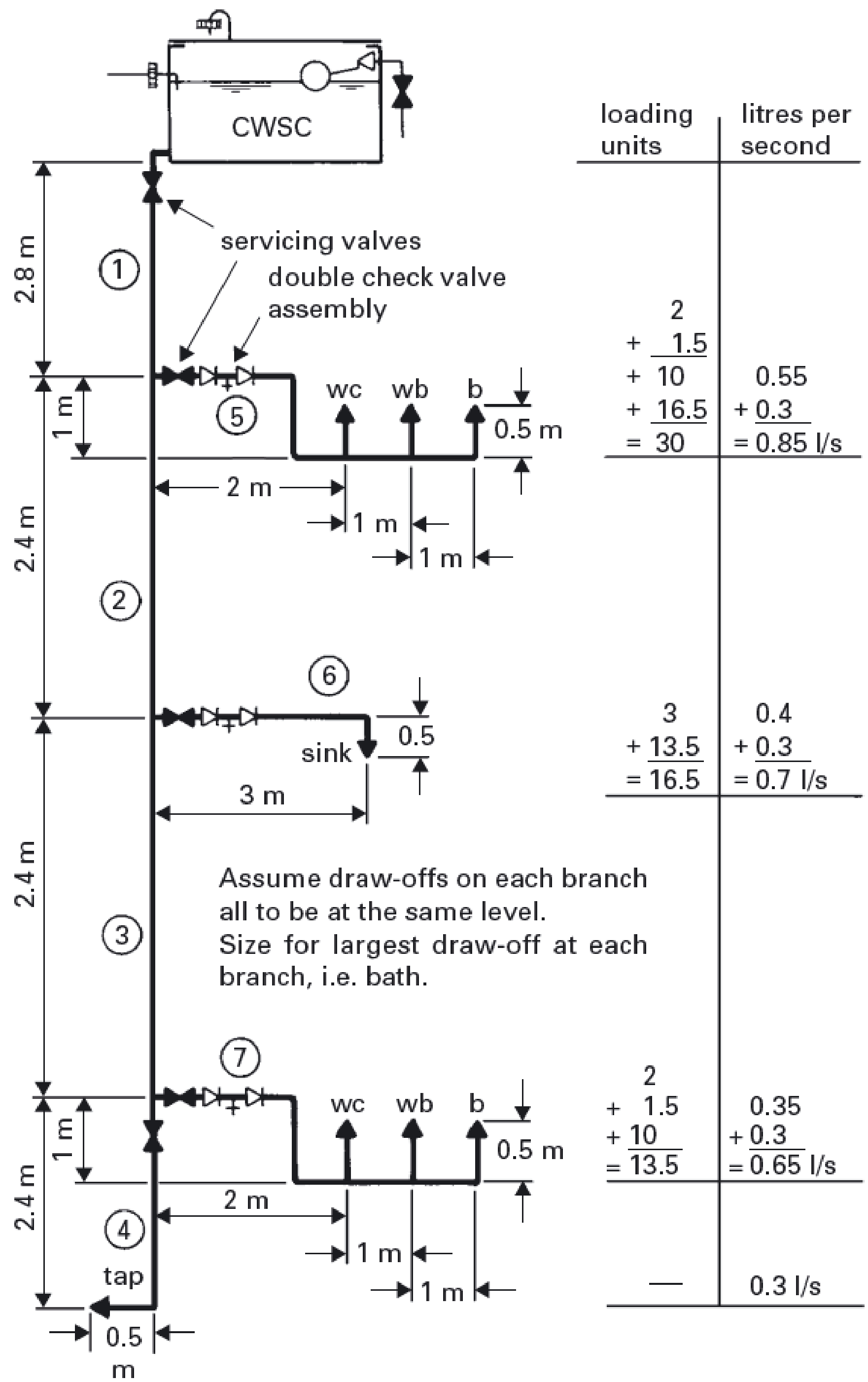
See Figure 4.12, using the data shown in Figures 4.11 and 4.13.

Estimated maximum demand = 1.4 l/s
Probable demand = 0.85 l/s

$$\text{Percentage demand} = \frac{\text{probable demand}}{\text{estimated maximum demand}} \times \frac{100}{1}$$

$$= \frac{0.85}{1.4} \times \frac{100}{1} = 60\%$$

Therefore only 60% of the installation need be considered. For example, if we were designing for a multi-storey building 20 storeys high, only the first 12 storeys need to be calculated. However, in the example followed here, the whole system has been sized because the last fitting on the run has a high flow rate in continuous use. For branches only the pipes to the largest draw off, i.e. the bath tap, need be sized.



Bib tap at 0.3 l/s in frequent use.

Note Figure is not to scale for convenience, water level in cistern taken to be at base of cistern. Servicing valves assumed to be full-flow gate valves having no head losses.

Refer also Figure 4.13

Figure 4-11 Pipe sizing diagram

Enter pipe references on calculation sheet	(1) Pipe reference
Determine loading unit (table 4.8)	(2) Loading units
Convert loading units to flow rate (figure 4.4)	(3) Flow rate (l/s)
Make assumption as to pipe size (inside diameter)	(4) Pipe size (mm diameter)
Work out frictional resistance per metre (figure 4.10)	(5) Loss of head (m/m run)
Determine velocity of flow (figure 4.10)	(6) Flow velocity (m/s)
Measure length of pipe under consideration	(7) Measured pipe run (m)
Consider frictional resistances in fittings (table 4.11 and figures 4.8 and 4.9	(8) Equivalent pipe length (m)
Add totals in columns 7 and 8	(9) Effective pipe length (m)
Head consumed-multiply column 5 by column 9	(10)Head consumed (m)
Add head consumed in column 10 to progressive head in previous row of	(11)Progressive head (m)
Record available head at point of delivery	(12)Available head (m)
Compare progressive head with available head to confirm pipe diameter or not	(13)Final pipe size (mm)
Notes	(14)Remarks

Figure 4-12 Calculation sheet – explanation of use

(1) Pipe reference	(2) Loading units	(3) Flow rate (l/s)	(4) Pipe size (mm diameter)	(5) Loss of head (m/m run)	(6) Flow velocity (m/s)	(7) Measured pipe run (m)	(8) Equivalent pipe length (m)	(9) Effective pipe length (m)	(10) Head consumed (m)	(11) Progressive head (m)	(12) Available head (m)	(13) Final pipe size (mm)	(14) Remarks
1	30	0.85	32	0.05	1.2	2.8	1.4	4.2	0.21	0.21	2.8	32	
5	13.5	0.35	20	0.095	1.25	5.5	12.0	17.5	1.66	1.87	3.3	20	
2	16.5	0.7	25	0.12	1.5	2.4	–	2.4	0.29	2.16	5.2	25	
6	3	0.3	20	0.07	1.0	3.5	10.4	13.9	0.97	3.13	5.7	20	
3	13.5	0.65	25	0.1	1.4	2.4	–	2.4	0.24	3.37	7.6	25	
7	13.5	0.35	20	0.095	1.25	5.5	12.0	17.5	1.66	5.03	8.1	20	
4	—	0.3	20	0.07	1.0	2.9	1.6	4.5	0.31	5.34	10.0	20	

Refer also fig. 4.11

Figure 4-13 Calculation sheet – example of use

4.8.4 Distribution system in multi-story buildings

4.8.4.1. Direct Supply System

(1) This system shall be adopted when adequate pressure is available throughout the day at the municipal water distribution line which can satisfy the functionality requirements of the building or that is sufficient to reach an elevated water tank; and municipal water supply interruption is not expected.

4.8.4.1.1. Direct Supply to fixtures

(1) The water supply distribution line after the water meter shall be directly connected to sanitary fixtures without any storage.

4.8.4.1.2. Direct Supply to Elevated Water Tank

(1) The water distribution line after water meter shall be directly connected to elevated water tank and the fixtures are supplied via gravity from the elevated water tank.

4.8.4.2. Pumping System

(1) The system shall be adopted when the requirement under 4.8.4.1(1) is not fulfilled.
(2) The system shall be used where a constant and reliable supply of power is ensured.

4.8.4.2.1. Direct Pumping from the Water Supply Line

(1) Direct pumping from a water supply line could affect the municipal water supply system depending on the pressure in the system. Therefore, special approval from the water supply authorities be obtained before designing such a system.

(2) Direct pumping from water supply line to sanitary fixtures

a) The pump shall be connected to a water distribution line after the water meter and provides water to all fixtures without any storage.

b) Direct pumping systems shall be used for buildings where a certain amount of constant use of water is always occurring.

(3) Direct pumping from water supply line to elevated water tank

a) The pump shall be connected to a water distribution line after the water meter and delivers to an elevated water tank from which fixtures are supplied via gravity.

4.8.4.2.2. Direct Pumping from ground reservoir to elevated water tank

(1) The municipal water shall be stored at ground or low level water reservoir and be pumped to elevated or roof water tanks as shown in Figure 4.14.
(2) Water collected in the elevated or overhead tank shall be distributed to the various parts of the building or fixtures via gravity system.
(3) Care shall be taken to avoid dry running of pump when the water level in the lower reservoir reaches its minimum level.
(4) The system shall ensure automatic operation of the pumps by providing level control switches in the elevated water tank or approved control methods.

4.8.4.2.3. Direct pumping from ground reservoir using Hydro-Pneumatic Systems

(1) An operation of the pumps shall be regulated using an air-tight pressure vessel as shown in Figure 4.15.
(2) The vessel capacity shall be based on the cut-in and cut-out pressure of the pumping system depending upon allowable start/stops of the pumps and capacity shall be determined by approved standard or manufacturer recommendation.
(3) Adequate capacity clean/filtered and free from oil of compressed air shall be connected to feed air into the vessel, so as to maintain the required air-water ratio within the system.

4.8.4.2.4. Direct pumping from ground reservoir using Variable Speed Drive Pumps

(1) Variable speed drive pumping system shall be used where a pump with a large variation in its pressure-discharge and speed of the pump is efficiently used to deliver water at rates of flow as required by the system by changing its speed by varying it with the assistance of an electronic device which will reduce the rate of flow from speed of the motor about 960 rpm to 3000 rpm.
(2) Proper dry running protection shall be provided to protect bearings and shaft seals from being damaged using inlet pressure of the booster system or the level in the water reservoir.
(3) Expansion joints shall be installed in the suction and delivery sides of the pump system to:
(a) absorb expansion/contractions in the pipe work caused by changing liquid temperature
(b) reduce mechanical strains in connection with pressure surges in the pipe work
(c) isolate mechanical structure born noise in the pipe work (only rubber bellows expansion joints)
(4) It is advisable to isolate the booster system foundation from building parts by means of vibration dampers to prevent the transmission of vibration to buildings.

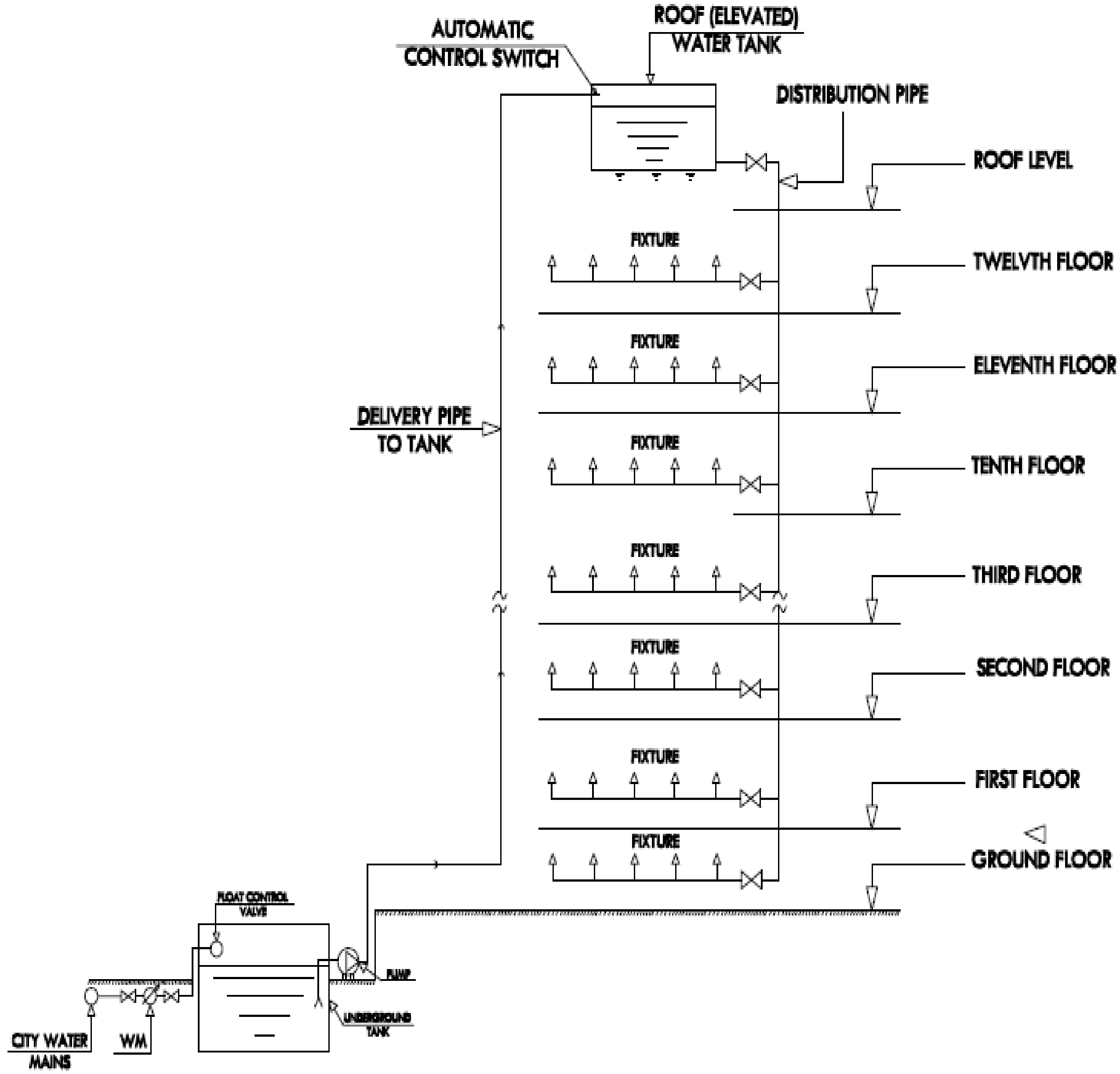


FIGURE 4.14 ELEVATED TANK DISTRIBUTION

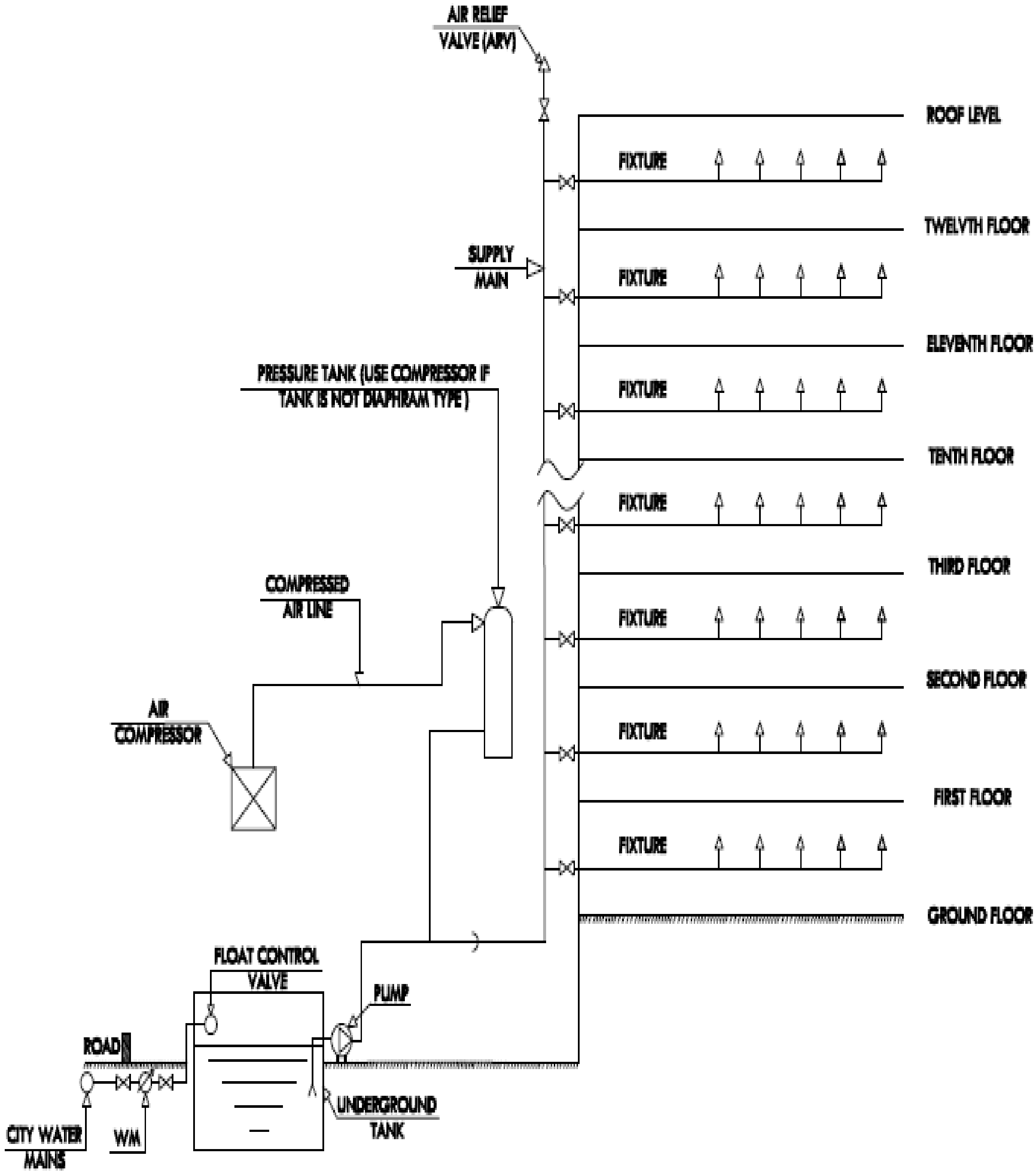


FIGURE 4.15 HYDRO-PNEUMATIC SYSTEM

4.8.5 Water Pressure, Pressure Regulators, Pressure Relief Valves and Vacuum relief Valves

4.8.5.1 Inadequate Water Pressure

(1) Whenever the water pressure in the main or other source of supply will not provide a residual water pressure of at least 5 meters (0.5bar), after allowing for friction and other pressure losses, tank and a pump or other means which will provide said fifteen shall be installed.

(2) Whenever fixtures and /or fixture fittings are installed that require residual pressure higher than fifteen 5meters (0.5bar), that minimum residual pressure shall be provided.

4.8.5.2 Excessive Water Pressure

(1) Where local static water pressure is high an approved type pressure regulator shall be installed.

(2) Approved regulators with integral bypasses shall be acceptable.

(3) Each such regulator and strainer shall be accessibly located and shall have the strainer readily accessible for cleaning without removing the regulator or strainer body or disconnecting the supply piping.

4.8.5.3 Pressure Relief Valves

(1) Any water system provided with a check valve, backflow preventer, or a pressure-regulating device which does not have a bypass feature at its source shall be provided with as approved, listed adequately sized pressure relief valve or a means to control expansion.

(2) Relief valves located inside a building shall be provided with a drain, not smaller than the relief valve outlet.

(3) No shutoff valve shall be installed between the relief valve and the system or in the drain line.

4.8.5.4 Vacuum Relief Valves

(1) Where a hot-water storage tank or an indirect water heater is located at an elevation above the fixture outlets in the hot-water system, a vacuum relief valve shall be installed on the storage or heater.

4.9 Hot water supply installation

4.9.1 Design Consideration

(1) The hot water services shall be designed to provide, so far as is practicable, hot water at the locations, in the quantities and at the temperatures required by the user at the least overall cost, taking account of installation, maintenance and energy costs.

(2) In electric water heating the common practice for domestic purposes is to use storage heaters in which water is steadily heated up to a predetermined temperature and stored until required for use.

(3) In modern hotels and apartment blocks and service apartments, centralized storage and distribution systems are adopted, where other energy sources such as oil, gas, heat pumps, solar panels, etc, may be used for the generation of hot water as these options prove more economical and convenient in heating large volumes of water for storage.

(4) When water supplied to the buildings contain dissolved salts resulting in hardness of water, measures such as installation of water softening plants etc shall be taken to avoid formation of scales in the hot water installations.

4.9.2 Storage Temperature and Capacity

(1) The design of hot water supply system and its appliances shall be based on the temperatures at which water is normally required for the various uses.

(2) In order to minimize the danger of scalding, precipitation of scale from hard water, standing heat losses, risk of steam formation and the possibility of damage to porcelain or other fittings and to surface finishes, a storage temperature of 60 °C shall be maintained. If soft water is used a temperature up to 65 °C may be adopted.

(3) The size of the storage vessel shall be governed by the maximum short time demand of the domestic premises depending on local conditions. The capacity of the storage vessel shall not be less than 20 percent in excess of the required maximum short time demand. For domestic uses the minimum capacity is recommended to be:

a) 80 liter to 100 liter at 60°C in a dwelling with a bath tub
b) 50 liter to 80 liter at 60°C for a shower
c) Storage heaters of 10 liter to 30 liter 60°C may be used to supply one or two points of draw offs depending on the use of hot water.
d) In larger houses where a single hot water heater is intended to supply hot water to more than one bathroom or kitchen or both, the maximum short time demand shall be estimated and the capacity decided accordingly.

(4) Values of volume of hot water required for a bath, when cold water is mixed with it depends on the supplied hot water temperature and are given in Table 4.12.

Table 4-12 Volume of hot water required for mixing with cold water for bathing

Storage temperature, °C	75	70	65	60	55	50
Percentage of hot water required	51	55	60	66	73	82.5
Quantity of hot water in liter required for a 115 liter bath	59	63	69	76	84	95

NOTE — Hot bath temperature at 41°C and cold water at about 5 to 5.5 °C

(5) For on-domestic uses, hot water consumption values shall be taken from good engineering practices in agreement with the building official

(6) The hot water storage vessel shall be fitted with a thermostat, safety valves and drain valves

4.9.3 Rate of Hot Water Flow

With storage type installation, the recommended minimum rates of flow for different types of fixtures are given in Table 4.13.

Table 4-13 Rate of hot water flow

Item	Fixtures	Rate of Flow (liters/min)
1.	Bath tub	22.5
2.	Kitchen sinks	18.0
3.	Wash basin	7.0
4.	Shower (spray type)	7.0

4.9.4 Materials, location and Installation of hot water storage tanks (Vessel)

1) Materials

a) Under no circumstances shall un galvanized (black) mild steel pipes and fittings be used in any part of a hot water installation, including the cold feed pipe and the vent pipe.

b) Materials resistant to the chemical action of water supplied shall be used in construction of vessels and pipes.

c) Each installation shall be restricted to one type of metal only, such as all copper or all galvanized mild steel.

d) When water supplied is known to have appreciable salt content, galvanized iron vessels and pipes shall not be used.

e) Where required it is also advisable to use vessels lined internally with glass, stainless steel, etc.

2) The suitability of galvanized mild steel for storage tanks depends upon the pH value of the water and the extent of its temporary hardness. For values of pH 7.2 or less, galvanized mild

steel shall not be used. For values of pH 7.3 and above, galvanized mild steel may be used provided the corresponding temporary hardness is not lower than those given in Table 4.14.

Table 4-14 pH and required minimum temporary hardness to use galvanized mild steel for hot water storage

pH Value	Minimum Temporary Hardness Required(mg per liter)
7.3	210
7.4	150
7.5	140
7.6	110
7.7	90
7.8	80
7.9-8.5	70

(3) Location of Storage Vessel.

a) The storage vessel shall be so placed that the pipe runs to the most frequently used outlets are as short as possible in order to minimize heat loss through pipes.

(4) Thermal Insulation of Storage Tanks.

a) The hot water storage vessel and pipes shall be adequately insulated wherever necessary to minimize heat loss.

b) The whole external surface of the storage vessel including the cover to the hand hole, shall be provided with a covering equivalent to not less than 75mm thickness of thermal insulating material having a conductivity of not more than 0.05 W/(m²,°C)/mm at mean temperature of 50°C.

4.9.5 Types of System

4.9.5.1 General

(1) The choice of the hot-water heating system (between instantaneous and hot-water storage system) shall be made bearing in mind the objectives expressed in Clause 4.9.1 and the characteristics of the different systems. Furthermore, the system shall be sized to meet the requirements of the user as closely as possible.

4.9.5.2 Instantaneous system

(1) In the instantaneous system, the water is heated as used, there is no storage, and the capacity of the heater shall be equal to the peak demand.

(2) Gas-fired instantaneous water heaters installed in bath rooms shall be of the room-sealed type.

4.9.5.3 Storage system

(1) In the storage system, hot water is heated continuously or intermittently as desired.

(2) The choice between the vented and the non-vented type of installation of the storage system shall be in accordance with the factors described below;

(a) Vented hot-water storage systems are fed with cold water from a storage cistern which is situated above the highest outlet to provide the necessary pressure in the system and which accommodates expansion of the water when it is heated. An open vent pipe shall be installed from the top of the hot water storage vessel to a point above the cold water storage cistern, into which it is arranged to discharge. The main characteristics of vented systems are:

(i) Explosion protection is provided by the open vent pipe and the cistern, involving no mechanical device;

(ii) The storage provides a constant low pressure and needs to be protected against the ingress of contaminants.

(b) Non-vented systems can be fed from a storage cistern, either directly or through a booster pump or fed from the municipal supply pipe, either directly or via a pressure reducing valve. The main characteristics of non-vented systems are as follows;

(i) Explosion protection is provided by safety devices that need periodic inspection and maintenance.

(ii) They allow quicker installation than vented system but involve more costly components.

4.9.6 Cold Feed and Hot Water Distribution Pipes

4.9.6.1 Cold feed pipes

(1) Connection to hot water storage vessels shall be arranged so that the cold water feed pipe is connected near to bottom of the vessel.

(2) The cold feed pipe shall be sized in accordance with Clause 4.8.3

4.9.6.2. Hot water Distribution Pipes

(1) In systems incorporating a hot water storage vessel, the hot water draw-off shall be arranged to be from the top of the vessel, or as near as there to as practicable.

(2) The hot water distribution pipe shall be sized in accordance with Clause 4.8.3

(3) To promote maximum economy of energy and water, the hot water distribution system shall be designed so that the hot water appears quickly at draw-off-taps when they are opened.

(4) (a) The length of pipe measured from the tap to the water heater or hot water storage vessel shall be as short as possible and should not exceed the values given in Table 4.15

(b) Where the length shown in Table 4.15 is exceeded, the pipe should be insulated.

Table 4-15 Maximum lengths of un insulated distributing pipes

Outside diameter of distributing pipe [mm]	Maximum length [m]
Not exceeding 12	20
Exceeding 12 but not exceeding 22	12
Exceeding 22 but not exceeding 28	8
Over 28	3

4.9.6.3 Hot water recirculation

(1) When draw-off points are situated at a distance from the hot water storage vessel or water heater, consideration should be given to the use of separate water heater close to those draw-off points.

(2) When the provision in (1) above is impracticable, re-circulation with flow and return pipes to the storage vessel should be considered and the circuit should be well insulated to reduce the heat losses from pipe runs.

(3) In systems where it is not possible to attain gravity circulation, a non-corroding circulating pump shall be installed to ensure that water within the circuit remains hot.

4.9.7 Safety Devices

4.9.7.1 Energy control

(1) The energy supply to each heater shall be under effective thermostatic control to prevent the temperature of the stored water from rising above the normal expected hot water temperature.

(2) The energy supply to each heater shall be fitted with a temperature operated, manually reset energy cut-out independent thermostatic control, which shall operate if the thermostat fails and the storage vessel over heats.

(3) Adequate means of dissipating the heat input shall be made in case both the temperature thermostat and the energy cut-out fail. This can be accomplished with either of the following.

(a) A vent pipe capable of carrying away the maximum energy output from the heater at the normal working pressures of the system.

(b) A temperature relief valve located within the top 20% of the water in the vessel and preferably within 150.0 mm of the top of the vessel. The temperature relief valve opens at a preset temperature to permit the over-heated water to escape safely from the hot water storage heater before it boils. Valves shall not be fitted between the temperature relief value and the heater. The water discharged from the temperature relief valve must be removed from the point of discharge to a safe place.

4.9.7.2 Pressure control

(1) (a) Whether hot or cold water is involved, it shall be ensured that no part of the system bursts due to the hydraulic pressure to which it is subjected.

(b) The pressure in the system shall never exceed the safe working pressure of the component parts.

(c) Where necessary, the supply pressure shall be controlled by break cisterns or by pressure-reducing valves.

(2) (a) Where non-vented storage-type water heaters are used, an expansion relief valve shall be fitted in the cold feed to the heater and no valves (other than a draining tap) shall be fitted between the expansion relief valve and the heater or hot water storage vessel. The expansion or pressure relief valve setting shall be the maximum working pressure plus 0.5kg/cm^2 to 1.5kg/cm^2.

(b) Any water discharged from an expansion valve shall be discharged safely in a similar manner to that of temperature-relief valve.

(c) In addition, provision can also be made to accommodate expansion water by one of the following alternative methods:

(i) Allow the expansion water to travel back along the cold feed pipe, provided that heated water cannot reach any branch cold feed outlet.

(ii) Where reverse flow along the cold feed is prevented, e.g. by check valve or pressure reducing valve, an expansion vessel shall be provided to accommodate expansion water. This vessel shall be sized in accordance with the volume of water heated and the water temperature rise so as to limit the pressure to the maximum working pressure of the system. The expansion vessel shall accommodate an expansion equal to 4% of the total volume of heated water.

4.10 Water Service Pipe

(1) The water service pipe from street mains to a building shall be of sufficient size to furnish an adequate flow of water to meet the requirements of the building and should preferably be not less than 20.0 mm nominal diameter.

4.11 Minimum Pressure

(1) Minimum, fairly constant residual pressure at the point of outlet discharge shall not be less than 0.50 kg/cm^2 for all appliances except for flush valves and special equipment (which may require higher pressures) valves in accordance with manufacturer’s requirements can be taken.

4.12 Water Hammer

(1) Where water pressures are excessive, air chambers or other approved mechanical devices shall be provided to reduce water hammer or line noises to such an extent that no pressure hazard to the piping system will exist.

4.13 Installation of Pipe Work in Buildings

4.13.1 General

(1) All joints shall be gas-tight and water-tight, and no paint, varnish, or putty shall be permitted on the joint until after the joint has been tested and approved.
(2) All joints shall be made in accordance with the manufacturer's instructions.
(3) Care shall be taken to establish satisfactory jointing techniques for all water services pipe work.
(4) All piping and fittings shall be cleaned internally and be made free from particles of sand, soil, metal fillings and chips.

4.13.2 Handling of Materials

(1) Pipes, fittings, and components shall be handled carefully to reduce damage.

(2) Manufacturers' advice should be followed concerning how their products should be loaded, transported, unloaded and stored.

4.13.3 Allowance for Thermal Movement

(1) In installation that do not have limited straight runs and many bends and offsets, allowance for expansion and construction of the pipes shall be made by forming expansion loops, by introducing changes of direction avoid long straight runs or by fitting proprietary expansion joints. This is particularly important where temperature changes are considerable (e.g. hot water distribution pip work) and where the pipe material has a relatively large coefficient of thermal expansion (e.g. un-plasticized PVC).

(2) In installation with limited straight runs and many bends and offsets, thermal movement is accommodating automatically.

4.13.4 Accessibility Pipes and Water Fittings

4.13.4.1 General

(1) A designer of a water supply system should consider the advantage and disadvantages of arranging the pipe work so that it is freely accessible for repair and maintenance.

(2) The main factors that should be considered deciding the degree of accessibility to be provided are the following:

(a) The use to which building is put, importance of aesthetic considerations, consequences of leakage from inaccessible parts of the pipe work; whether or not the system will be subject to routine and maintenance.

(b) The increase or decrease in capital or maintenance costs arising from the provision of improved accessibility, ease of forming ducts or chases, changes of pipe runs, ease of provision removable access panels or covers, availability of multi-service walkways or crawl ways in which water pipes may be installed.

(c) The pipe work materials and jointing methods, reliability of joints, resistance to both internal and external corrosion, flexibility of pipe when inserted in curved ducts or sleeves.

4.13.4.2 Pipes Passing Through Walls and Floors

(1) Where a pipe passes into a building, it shall be arranged so as to accommodate differential movement and shall be accessible for withdrawal and replacement.

(2) Where a sleeve is used for this purpose, it shall be capable of resisting external loading and shall be sealed at each end with material of permanently flexible form to allow movement of the pipe.

(3) The diameter of the sleeve and the radius of any bends there in shall be such as to permit the ready insertion and withdrawal of the pipe.

(4) No sleeve intended for carrying a water pipe shall contain within it any other pipe or cable.

4.13.4.3 Pipe in Walls and Floors

(1) No pipe or pipe joint in or under a building shall be embedded in any wall or solid floor or in any material below a solid floor at ground level except for the following (unless equivalent method of installation satisfactory to the building official is made for the accessibility of pipes during inspection and maintenance);

(a) The embedding of any pipe and associated pipe joints in a properly formed chases in a wall or solid floor that is subsequently plastered or screened if the pipes or pope joints can be exposed for repair or replacement by cutting or chipping away the surface layers of the plaster or screed.

(b) The enclosing of any pipe and associated pipe joints in a purpose-made duct or chase in a solid floor in such a way that the pipe and pipe joints can be exposed for purpose of examination, repair or replacement without endangering the structural integrity of the building.

(c) The enclosing of any pipe and associated pipe joints in a purpose-made chase in a solid wall in such a way that the pipe and pipe joints can either be capped off and isolated or be exposed for purposes of examination, repair or replacement without endangering the structural integrity of the building.

4.13.4.4 Pipes in ceilings

(1) Pipes and pipe joints installed in ceilings shall be assessable for purposes of examination, repair or replacement and supported adequately as specified in Clause 3.10.

4.13.4.5 Underground Stop Valves

(1) Valve chambers shall be provided to give access for operation and maintenance of underground valves which may be made of brick or concrete.

(2) Alternatively, vertical guard pipes or precast concrete encasement can be provided to enclose valves.

(3) Brick or concrete chamber shall be constructed of sufficient dimensions to permit repairs to be carried out to the fittings.

4.13.4.6 Aboveground Valves

(1) Every valve shall be sp placed that it is readily accessible for operation and maintenance.

(2) Any cover shall be fixed by removable fastenings.

4.13.4.7 Cisterns

(1) Every storage cistern shall be so placed and equipped that the interior there of can be inspected and cleaned and the float-operated valve can be maintained.

4.13.5 Support & fixing of pipes

4.13.5.1 General

(1) Piping shall be retained in position by brackets, clips or hangers.

(2) Brackets, clips and hangers shall be:

(a) Formed of suitable materials;
(b) Securely attached to the building structure, and not to any other service;
(c) Designed to withstand the applied loads;
(d) Protected against corrosion where exposed to corrosive environment;
(e) Of like material or lined with a non-abrasive, inert material for that section where contact with the pipe work many occur; and
(f) Installed so that no movement can occur while a valve is operated.

(3) The method of supporting of spacing of pipes by means of brazing or welding a short section of any material to the surface of each pipe shall not be permitted.

4.13.5.2 Spacing for pipe fixings

(1) The spicing for fixings of internally located piping shall be in accordance with Table4.16.

4.13.5.3 Fixing of iron pipe

(1) Iron pipes shall be secured by heavy weight holder-bats of iron or low carbon steel either built in or bolted to the structure.

4.13.5.4 Fixings for copper and stainless steel pipe

(1) Copper and stainless steel piping shall be secured by copper, copper-alloy, plastics clips or brackets.

4.13.5.5 Fixings for steel pipe

(1) Steel piping shall be secured by steel, copper alloy, suitable plastics clips or brackets. Copper clips or brackets shall not be used for fixing steel piping.

4.13.5.6 Fixing for plastic pipes

(1) Plastics piping shall be secured by suitable metal, plastic lips or brackets. Allowance shall be made for free lateral movement within the clips and brackets.

4.13.5.7 Fixing of insulated pipes

(1) Piping that is insulated shall be secured on clips or brackets that allow sufficient space behind the back of the pipe and the batten or wall to which the pipe is fixed for the insulation to be properly installed.

4.13.5.8 Concealed pipes

(1) Piping shall be housed in properly constructed builder work ducts or wall chases with adequate supports and have access for maintenance and inspection in accordance with Clause 4.13.4.

4.13.5.9 Clearance from structural members

(1) Piping laid through notched, holes or chases shall not be subjected to external pressure and shall be free to expand or contract. Piping though walls and floors shall be sleeved.

Table 4-16 Spacing of bracket and clips

Nominal pipe size	Maximum spacing of brackets and clips [m]					
	Steel pipes		Copper pipes		Un-plasticized PVC, and polyethylene pipes	
	Horizontal or graded pipes	Vertical pipes	Horizontal or graded pipes	Vertical pipes	Horizontal or graded pipes	Vertical pipes
DN15	2.0	2.4	1.80	1.50	0.60	1.20
DN20	2.4	3.0	2.40	1.80	0.70	1.40
DN25	2.4	3.0	2.40	2.00	0.75	1.50
DN32	2.7	3.0	3.00	2.50	0.85	1.70
DN40	3.0	3.6	3.00	2.50	0.90	1.80
DN50	3.0	3.6	3.00	3.00	1.05	2.10
DN65	3.0	3.6	3.00	3.00	1.20	2.40
DN80	4.0	4.5	4.00	4.00	1.35	2.70
DN100	4.0	4.5	4.00	4.00	1.50	3.00
DN125	4.5	5.0	4.00	4.00	1.70	3.40
DN150	4.5	5.5	4.00	4.00	2.00	4.00

Note: Due to water pressure effects, additional brackets, clips or hangers may be required to prevent movements.

4.13.5.10 Proximity to other services

(1) Electrical cables and gas pipes shall not be installed within 100.0mm of any water service.

4.14 Underground Pipe Laying

4.14.1 Trench Excavations

(1) The bottom of trenches shall be carefully prepared to a firm surface so that the barrels of the pipes, when laid, are well bedded for their whole length.

(2) Mud, rock projections, boulders, hard sport and local soft spots shall be removed and replace with selected material consolidated to the required level.

(3) Pipes laid in the ground shall be provided with a minimum cover given in Table 4.17

4.14.2 Bedding and Backfilling

(1) In the refilling of trenches, the pipes shall be surrounded with not less than 75.0 mm of compacted sand, or fine grained soil, with no hard-edged object permitted to come in contact with or rest against any pipe or fitting (see Figure 4.16).

(2) Any back fill within 300.0 mm of the top of the pipe shall be free from builder's waste bricks, concrete pipes, rocks or similar material which would be retain on a 75.0 mm sieve.

Table 4-17 Minimum cover of pipes

Location	Minimum cover measured below ground surface level [mm]
Subject to vehicular traffic	750
All other locations	600

Note: For pipes to be buried in heavy truck areas, special consideration shall be taken to protect them from damage.

4.14.3 Proximity to Other Services

(1) Electrical cables and gas pipes shall not be installed within 600.0mm of either side of a below ground water service. Wherever this separation cannot be achieved, the distance from any electrical cable or gas pipe may be reduced to 300.0mm provided that, within the exclusion zone, such electrical cable or gas pipe is suitably marked with bricks, stone masonry or equivalent durable material painted red.

(2) Any below-ground cross-over of water service, within the exclusion zone, shall:

(a) cross at angle not less than 45°

(b) have a vertical separation of not less than 100.0mm, and

(c) be suitably marked with bricks, stone masonry or equivalent durable material, painted red.

(3) Water service pipes shall not be laid in a trench excavated for a foul drain. Wherever it is not practical to do otherwise, water pipes may be laid in the same trench as a sanitary drain (see Figure 4.17) provided the following conditions are observed:

(a) The water service shall be located on a shelf or ledge, excavated at one side of the trench not less than 50.0mm from the continuation of the trench, or on compacted bedding.

(b) The underside of the water pipe is at least 100.0mm above the top of foul drain.

(c) The number of joints in the water service pipe shall be kept at a minimum

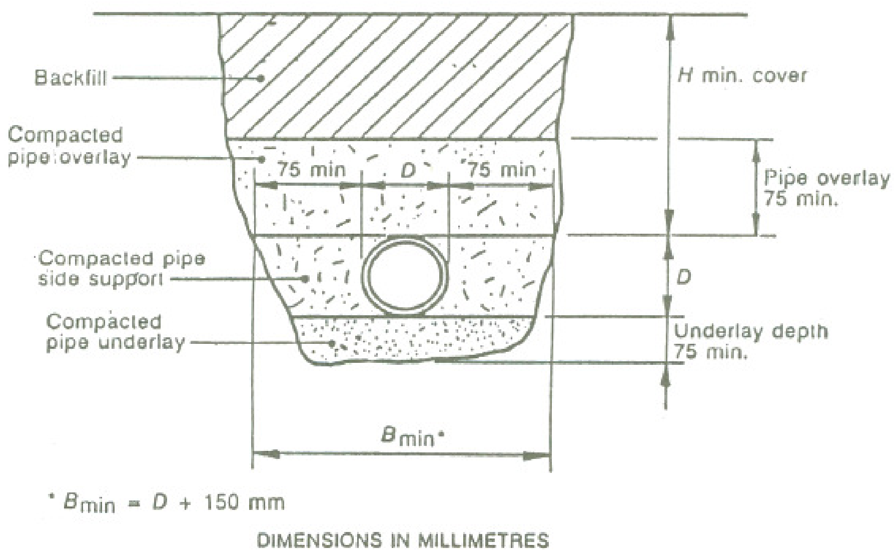


Figure 4-16 Typical installations in a trench

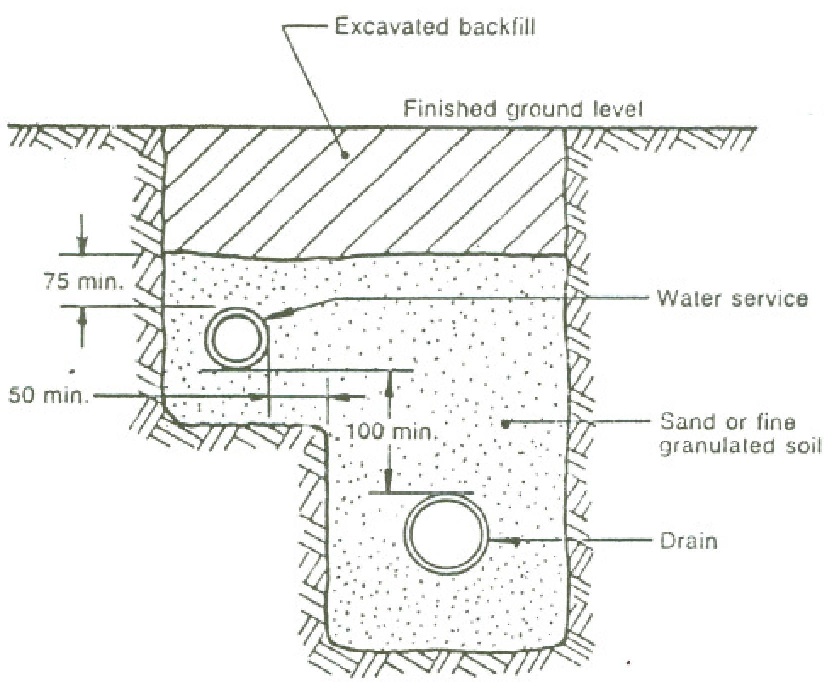


Figure 4-17 Laying of water supply pipe work in same trench as foul drains

4.14.4 Ingress of Dirt

(1) Pipes shall be kept clean and, immediately before laying each pipe and fitting, shall be thoroughly cleaned internally and the open end temporarily capped until jointing takes place. Particular care shall be taken to keep the joints clean. After laying and jointing, the leading end shall remain capped.

4.14.5 Corrosion

(1) Pipes passing through corrosive materials shall be provided with approved coatings, sheathings or wrappings or other means of protection against damage from external corrosion.

(2) Where ferrous and non-ferrous pipes or fittings are jointed together, protection against galvanic corrosion shall be provided by:
- (a) fitting a plastic connector or a short length of plastic pipe between the dissimilar metals, for threaded type joints, or
- (b) fitting an insulated gasket between flanges, insulating sleeves along the bolts, and insulating washers under the bolt head and nut, for flange type joints.

4.14.6 Thrust Blocks

(1) Thrust bocks (see Figure 4.18) shall be installed at:
- (a) All bends or junctions,
- (b) The termination of pipe work,
- (c) Valves installed in the pipe work,
- (d) The reducing fitting in the direction of smaller pipe,
- (e) Changes of direction in excess of 5°, and
- (f) Grades in excess of 1:5.

(2) Thrust blocks shall be constructed of concrete with one side bearing against a firm vertical face of the excavation and designed to resist the thrust produced by the test pressure to be transmitted to the surrounding soil without the maximum bearing pressures of the soil and the pipe work material being exceeded.

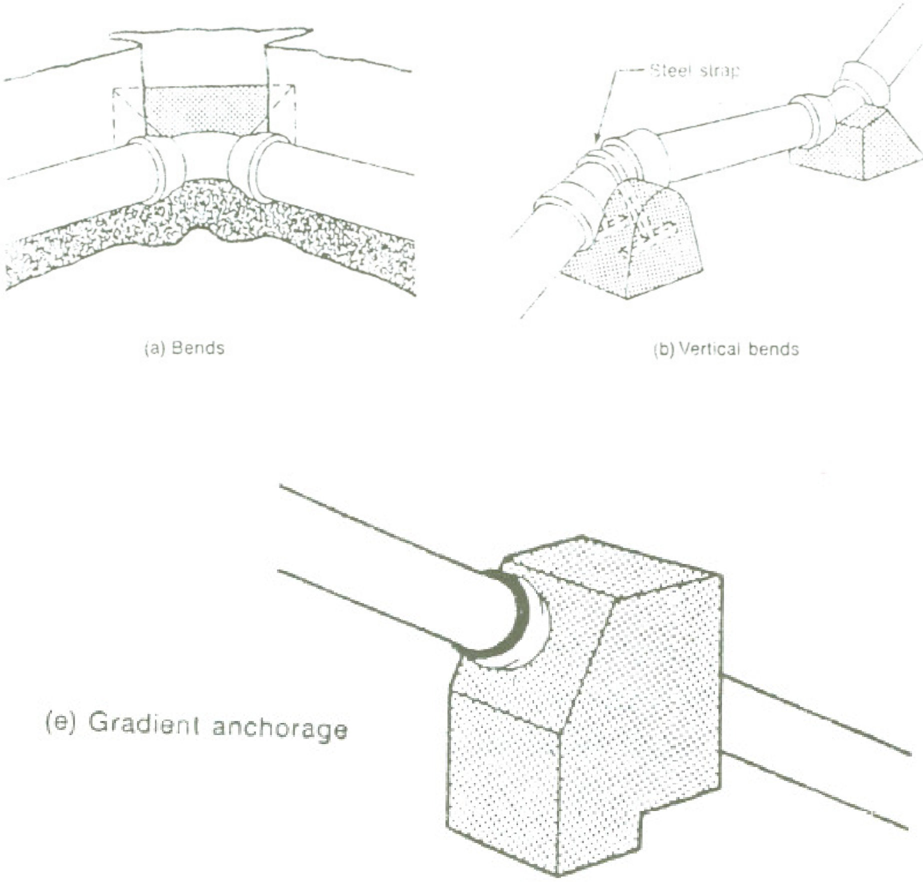


Figure 4-18 Typical location of thrust blocks

4.15 Identifying and Recording Piping Locations

4.15.1 Location of Pipes and Valves

(1) Consideration shall be given to the need to locate the position of pipes and valves.

(2) Valve chambers shall be letter-coded to indicate what service is below them where possible, durable marks should be set up to indicate the pipe service, the size, the position and depth below the surface.

(3) In any building other than a single dwelling, every domestic and fire fighting water supply pipes shall be clearly and indelibly marked to distinguish them from each other and from every other pipe in the building.

(4) All pipes conveying non-potable water shall be adequately and durably identified by a distinctive coloring paint so that they will be readily distinguished from pipes carrying potable water.

4.15.2 Recording Drawings

(1) During the installation of a water supply system, records of all pipe runs, cisterns, valves, outlets, etc. shall be kept.

(2) On completion of the work, drawings shall be prepared on durable material of the "as fixed" installation. These record drawings shall be handed to the "building owner".

4.16 Inspection and Testing

4.16.1 General

(1) The procedures detailed in this section shall be used to ensure that:

(a) Materials and equipment installed comply with approved standards (see Clause 4.2)

(b) The work is done entirely within the specification for the job.

(c) The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as rejected and forthwith removed from the site.

4.16.2 Procedure

4.16.2.1 General

(1) Inspection and tests shall be undertaken as the work proceeds. Records of all tests required by the specification shall be kept by the installer.

4.16.2.2 Timing

(1) The timing of tests shall be arranged as follows:

(a) Interim tests – as soon as practicable after completion of the particular section, with particular attention to all work which will be concealed.

(b) Final tests – to be carried out on completion of the work on the water services and prior to handing over.

(2) Satisfactory completion of an interim test shall not constitute a final test.

4.16.2.3 Retests

(1) Items failing any tests shall be corrected immediately and re-tested before further work proceeds.

4.16.3 Inspection

(1) Visual inspections shall be carried out at both interim and final testing in order to detect faults in construction or material not shown up under test but which could lead to failure at a later date, possibly after expiry of the contractual maintenance period.

(2) Internal pipe work: All internal pipe work shall be inspected to ensure that they are properly supported and secured, that they are clean and free from swarf and that cisterns are provided with correctly-fitting covers before testing takes place.

(3) Underground external pipe work
   (a) Trenches shall be inspected to ensure that excavation is to the correct depth to guard mechanical damage due to traffic or other activities.
   (b) In visual inspection of pipe lines laid in open trenches, particular attention shall be paid to the pipe bed, the line and the level of the pipe, irregularities at joints, the correct fitting of valves, the correct installation of thrust blocks where required, and ensure that protective coatings are undamaged.

4.16.4 Leakage Testing

4.16.4.1 General

After satisfactory visual inspection has been completed, hydraulic pressure testing shall be carried out on the installation. Compressed air may be used as well for the pressure test.

4.16.4.2 Testing of Installations within Buildings

(1) When the installations is complete, it shall be slowly filled with water, with the highest draw-off point open to allow air to be expelled from the system.
(2) It is desirable that the installation then be tested hydraulically in the following way: Subject the pipes; pipe fittings and connected appliances to a test pressure of $10.0 kg/cm^2$ or at least two times the maximum working pressure, which ever is greater, with the pressure applied and maintained for at least 1.0 hr. The installation, including all cisterns, water heaters, etc shall then be inspected for leaks.
(3) Each draw-off tap, shower fitting and float-operated valve shall be checked for rate of flow against the specified requirements. Defects revealed by any of the foregoing tests shall be remedied and the tests repeated until a satisfactory result is obtained.

4.16.4.3 Testing of Underground Pipelines

(1) After laying, jointing and anchoring, the pipeline shall be slowly and carefully filled with water so that all air is expelled and then tested under pressure.
(2) Interim tests shall be applied to every pipeline. For buried pipelines, these shall be carried out before backfilling is placed over the joints. Long pipelines shall be tested as the work proceeds.
(3) Final tests shall be carried out only when all relevant work is complete. Completion for buried pipeline includes backfilling, compaction and surface finish.

(4) Generally, the tests should be conducted before the hand-over. Where long lengths of buried pipelines are laid clear of the general construction area, it may be practicable to carry out final tests for complete sections as work proceeds.

(5) (a) The test pressure shall be at least twice the maximum working pressure or 10.0 kg/cm^2, whichever is greater.

(b) Pressure gauges shall be checked and re-calibrated, where necessary, before the test.

(c) To avoid the risk of contamination, water used for testing shall be obtained from potable supply.

4.17 Cleaning and Disinfection

4.17.1 Storage tanks

(1) All water storage tanks for portable water shall be cleaned and disinfected:

(a) Prior to initial use; and

(b) Whenever the storage tank is taken out for inspection, repairs, painting or other activity that might lead to contamination of water.

(2) (a) The tank shall be drained and all debris and sludge removed.

(b) The surfaces of walls, floor and operating facilities shall be thoroughly cleaned using a high pressure water jet, sweeping, scrubbing or other similar effective means.

(c) All water, dirt, and other material accumulated in this cleaning process shall be flushed or otherwise removed from the tank.

(3) (a) After cleaning, the tank shall be disinfected by filling it to overflow level with potable water to which enough chlorine is added to provide a free chlorine residual, in the tank of not less than 10.0mg/l, at the end of retention time.

(b) The retention time shall not be less than 6.0 hr and the tank shall be drained after disinfection and flushed out with potable water prior to being put back into service.

4.17.2 Water services in buildings

(1) Water services used to supply potable water shall be protected against contamination during storage, construction and repairs that might lead to contamination of water.

(2) On completion of the installation or repairs, water services shall be flushed at each discharge point to remove any dirty water or debris from the service.

(3) After flushing, water services shall be chlorinated before being placed in service. Water services shall be disinfected, so that, after retention period of 6.0 hrs, a free chorine residual of not less than 10.0 mg/l is obtained throughout the service. After the applicable retention period, the service shall be flushed until chorine measurements show that the concentration in the water leaving the service is not higher than that generally prevailing in the suppliers distribution system or is acceptable for domestic use.

4.18 Maintenance

4.18.1 General

(1) Appropriate maintenance procedures shall be adopted to maintain the performance of the installation taking into account the requirements and recommendations given in Clauses 4.18.2 through 4.18.8.

(2) The installation shall be inspected at periods by the person responsible for maintenance. Faults noticed on inspection shall be attended to without delay.

4.18.2 Pipe work

4.18.2.1 Fixings and supports

Any loose or missing fixings or supports shall be made good. Provision for expansion and contraction shall be checked, particularly in the case of plastics pipe work.

4.18.2.2 Joints

Leaking joints shall be tightened or re-made or, where necessary, the pipe work shall be renewed, to stop all leakage.

4.18.2.3 Compatibility

When carrying out renewals, the existing pipe work shall be indentified and appropriate adaptor shall be used as necessary.

4.18.3 Terminal Fittings and Valves

4.18.3.1 Terminal fittings

(1) When any sign of leakage from a float-operated valve (e.g. dripping from any over-flow pipe) or tap is noticed, the fitting shall be re-washered, re-seated or replaced as necessary to stop leakage.

(2) The action of self- closing taps shall be checked at regular intervals and any necessary repairs or adjustments carried out.

4.18.3.2 Isolating valves

(1) Isolating valves (stop valves and service valves) shall be operated at least once a year to ensure free movement of working parts.

4.18.3.3 Relief valves

(1) Relief valves shall be operated at least once a year to check that the valve has not stuck or become blocked.

(2) Any fault revealed shall be corrected immediately.

4.18.3.4 Pressure control valves

(1) An indication of malfunction of pressure control valve shall be attended to without delay.

(2) When a pressure gauge is fitted downstream of a pressure control valve, its reading should be checked from time to time and any changes investigated.

4.18.4 Cisterns

(1) (a) Cisterns shall be inspected from time to time to ensure that overflow pipes are clean, that covers are adequate and securely fixed, and there are no signs of leakage or deterioration likely to result in leakage.

(b) Cisterns storing more than 1000.0 liter drinking water shall be inspected at least once every 6 months.

(c) Cisterns storing less than 1000.0 liter drinking water shall ne inspected at least once a year.

(2) (a) Overflow pipes shall be examined and kept free from obstructions.

(b) Ends of overflow pipes shall be protected from entry of insects and vermin.

4.18.5 Ducts

(1) Ducts shall be kept accessible, clear of extraneous material and free from vermin.

(2) All access points should be checked to ensure that they have not been obstructed

4.18.6 Vessels under Pressure

(1) Any vessel storing water under pressure (e.g non-vented storage water heaters) shall be inspected for indications of deterioration no less frequently than at the intervals recommended by the manufacturer.

4.18.7 Disconnection of Unused Pipes and Fittings

(1) If any part of an installation becomes redundant and, in particular, if any appliance or fitting is disconnected, other than for the purpose of repair, maintenance or renewal, then the whole of the pipe work supplying water to the disconnected or unused appliance or fitting shall also be disconnected.

4.18.8 Pumps

A responsible person should be appointed to oversee the proper execution of the scheme and the user should arrange for regular inspection and maintenance of the pump and equipment.

SECTION 5

5 INTERNAL DRAINAGE FOR BUILDINGS

5.1 General

5.1.1 Scope

This Section sets out requirements and standards.

(a) For the design, installation, testing and maintenance of Internal Drainage System for residential and non- residential buildings.

(b) The term Internal Drainage System includes all Soil and Waste-Water drainage pipe work within or on the buildings including any basement(s).

(c) This Section also sets out requirements regarding pipe materials and their jointing.

5.1.2 Basic Principles

5.1.2.1 Conservation Water

Plumbing system shall be designed, installed and adjusted to use the optimum quantity of water consistent with proper performance.

5.1.2.2 Plumbing Fixtures

It is recommended that each family dwelling unit should have at least one water closet, one lavatory, one kitchen wash place or a sink, and one bathing wash place or shower to meet the basic requirements of sanitation and personal hygiene.

5.1.2.3 Drainage System

The drainage system shall be designed, installed and maintained to guard against fouling, deposit of solids and clogging and with adequate cleanouts so arranged that the pipes may be readily cleaned.

5.1.2.4 Materials and Workmanship

The plumbing system shall have durable material, free from defective workmanship and so designed and installed as to give satisfactory service for its reasonable expected life.

5.1.2.5 Fixture Traps and Vent Pipes

Each fixture directly connected to the drainage system shall be equipped with a liquid seal trap, Trap seals shall be maintained to prevent sewer gas, other potentially dangerous or noxious fumes, or vermin from entering the building. Further, the drainage system shall be designed to provide an adequate circulation of air in all pipes with no danger of siphonage, aspiration, or forcing of trap seals under conditions of ordinary use by providing vent pipes throughout the system.

5.1.2.6 Foul Air Exhaust

Each vent terminal shall extend to the outer air and be so installed as to minimize the possibilities of clogging and the return of foul air to the building, as it conveys potentially noxious or explosive gases to the outside atmosphere. All vent pipes shall be provided with a cowl.

5.1.2.7 Exclusion from Plumbing System

No substance that will clog or accentuate clogging of pipes, produce explosive mixtures, destroy the pipes or their joints, or interfere unduly with the sewage-disposal process shall be allowed to enter the drainage system.

5.1.2.8 Light and Ventilation

Wherever water closet or similar fixture shall be located in a room or compartment, it should be properly lighted and ventilated.

5.1.2.9 Maintenance

Plumbing systems shall be maintained in a safe and serviceable condition.

5.1.2.10 Accessibility

All plumbing fixtures shall be so installed with regard to spacing as to be accessible for their intended use and for cleaning. All doors, windows and any other device needing access within the toilet shall be so located that they have proper access.

5.1.2.11 Fixture for Disabled

Special toilet fixtures shall be provided for the disabled with required fixtures and devices.

5.1.2.12 Structural Safety

Plumbing system shall be installed with due regard to preservation of the structural members and prevention of damage to walls and other surfaces.

5.1.2.13 Signage

Required public facilities shall be designated by a legible sign for each sex. Signs shall be readily visible and located near the entrance to each toilet facility.

5.2 Types of Appliances

5.2.1 Soil Appliances

5.2.1.1 Water-closet

It shall essentially consist of a closet consisting of a bowl to receive excretory matter, trap and a flushing apparatus. It is recommended to provide ablution tap adjacent to the water-closet, preferably on right hand sidewall. The various types/style of water-closets may be:

a) Squatting Indian type water closet,
b) Wash down type water closet,
c) Siphonic wash down type water closet, and
d) Universal or Anglo-Indian water closet.

5.2.1.2 Bidet

It is provided with hot and cold water connection. The bidet outlet should essentially connect to soil pipe in a two-pipe system.

5.2.1.3 Urinal

It is a soil appliance and is connected to soil pipe after a suitable trap. Urinal should have adequate provision of flushing apparatus. The various types/style of urinal may be:

a) Bowl type urinal: Flat back or Angle back,
b) Slab (single) type urinal,
c) Stall (single) type urinal,
d) Squatting plate type urinal, and
e) Syphon jet urinal with integral trap.

5.2.1.4 Slop sink and bedpan sink

Slop sink is a large sink of square shape. The appliance is used in hospitals installed in the nurse's station, operation theatres and similar locations for disposal of excreta and other foul waste for washing bed pans and urine bottles/pans. It is provided with a flushing mechanism.

5.2.2 Waste Appliances

5.2.2.1 Washbasin

It is of one piece construction having a combined overflow and preferably should have soap holding recess or recesses that should properly drain into the bowl. Each basin shall have circular waste hole through which the liquid content of the basin shall drain.

5.2.2.2 Wash-trough

It is a linear trough for simultaneous use by number of persons.

5.2.2.3 Sink

It is used in kitchen and laboratory for the purpose of cleaning utensils/apparatus and also serve the purpose of providing water for general usage. The sink may be made with or without overflow arrangement. The sink shall be of one piece construction including combined over flow, where provided. The sink shall have a circular waste hole into which the interiors of the sink shall drain.

5.2.2.4 Bath tub

Bath tub may be of enameled steel, cast iron, gelcoated, glass fiber reinforced plastic or may be cast-*in-situ.* It shall be stable, comfortable, easy to get in and out, water tight, with anti-skid base, and easy to install and maintain. The bath tub shall be fitted with overflow and waste pipe of nominal diameter of not less than 32 mm and 40 mm respectively.

5.2.2.5 Drinking fountain

It is a bowl fitted with a push button tap and a water bubbler or a tap with a swan neck outlet fitting. It has a waste fitting, a trap and is connected to the waste pipe.

5.2.2.6 Automatic Clothes Washers

5.2.2.6.1 Approval

Domestic automatic clothes washers shall satisfy Ethiopian Standards.

5.2.2.6.2 Water connection

The water supply to an automatic clothes washer shall be protected against backflow.

5.2.2.6.3 Waste connection

The waste from an automatic clothes washer shall discharge through an air break into a standpipe or into a laundry sink. The trap and fixture drain for an automatic clothes washer standpipe shall be a minimum of 2 inches (51mm) in diameter. The automatic clothes washer fixture drain shall connect to a branch drain or drainage stack a minimum of 3 inches (76mm)in diameter. Automatic clothes washer that discharge by gravity shall be permitted to drain to a waste receptor or an approved trench drain

5.2.3 Requirements of Various Appliances

The requirements of various soil appliances and waste appliances shall be in accordance with accepted standards.

5.3 Drainage System Requirements

5.3.1 General

(1) There should be at least one water tap and arrangement for drainage in the vicinity of each water-closet or group of water-closet in all the buildings.
(2) Each family dwelling unit on premises shall have, at least, one water-closet and one kitchen type sink. A bath or shower shall also be installed to meet the basic requirements of sanitation and personal hygiene.

(3) All other structures for human occupancy or use on premises shall have adequate sanitary facilities, but in no case less than one water-closet and one other fixture for cleaning purposes.

5.3.2 For Residences

(1) Dwelling with individual convenience shall have at least the following fixtures:
  (a) One bathroom provided with a tap and a floor trap;
  (b) One water-closet with flushing apparatus with an ablution tap; and
  (c) One tap with a floor trap or a sink in kitchen or wash place.

(2) Dwellings without individual conveniences shall have the following fixtures:
  (a) One water tap with floor trap in each tenement,
  (b) One water-closet with flushing apparatus and one ablution tap bath for every two tenements, and
  (c) One bath with water tap and floor trap for every two tenements.

5.3.3 For Buildings Other than Residences

The requirements for fixtures for drainage and sanitation in the case of buildings other than residences shall be in accordance with Table 5.1 to Table 5.14. The following shall be, in addition, taken into consideration:

(1) The figures shown are based upon one (1) fixture being the minimum required for the number of persons indicated or part thereof.

(2) Drinking fountains shall not be installed in the toilets.

(3) Where there is the danger of exposure to skin contamination with poisonous, infectious or irritating material, washbasin with eye wash jet and an emergency shower located in an area accessible at all times with the passage/ right of way suitable for access to a wheel chair, shall be provided.

(4) When applying the provision of these tables for providing the number of fixtures, consideration shall be given to the accessibility of the fixtures.

(5) All building used for human habitation for dwelling, work, occupation, medical care or any purpose detailed in the various tables shall be provided with minimum sanitary facilities as per the schedule in the tables.

(6) In all types of buildings, individual toilets and pantry should be provided for executives, and for meeting/seminar/conference rooms, etc as per the user requirement.

(7) Where food is consumed indoors, water stations may be provided in place of drinking water fountains

Table 5-1 Office Building

SI No. (1)	Fixtures (2)	Public Toilets: Male (3)	Public Toilets: Females (4)	Staff Toilets: Male (5)	Staff Toilets: Female (6)
	i) **Executive Rooms and Conference Halls in office buildings** Toilet suite comprising one WC, one washbasin (with optional shower stall if building is used round the clock at user's option) Pantry optional as per user requirement	Unit could be common for Male/Female or separate depending on the number of user of each facility		For individual officer rooms	
	ii) **Main Office Toilets for Staff and Visitors**				
	a) Water –closets	1 per 25	1 per 15	1 per 25	1 per 15
	b) Ablution tap with each water –closet	← 1 in each water–closet →			
	c) Urinals	Nil up to 6 1 for 7 – 20 2 for 21 -45 3 for 46 – 70 4 for 71 -100 101 -200 Over 200	-	Nil up to6	-
	Add @ 3% for				
	Add @ 2.5 %				
	d) Washbasins	1 per 25	1 per 25	1 per 25	1 per 25
	e) Drinking water fountain	1 per 100	1 per 100	1 per 100	1 per 100
	f) Cleaner's sink	← 1 per floor →			

Table 5-2 Factories

SI No. (1)	Fixtures (2)	Offices/ Visitors: Male (3)	Offices/ Visitors: Females (4)	Workers: Male (5)	Workers: Female (6)
i)	Water – Closets (Workers & Staff)	1 for up to 25 2 for 16 -35 3 for 36 -65 4 for 66 -100	1 for up to15 2 for 16 -25 3 for 26 -40 4 for 41 -57 5 for 58 -77 6 for 78 -100	1 for up to15 2 for 16 -25 3 for 26 -40 4 for 41 -57	1 for up to15 2 for 13 -25 3 for 26 -40 4 for 41 -57 5 for 58 -77 6 for 78 -100
	For persons 101-200 add	3%	5%	3%	5%
	For persons over 200 add	2.5 %	4%	2.50%	4%
ii)	Ablution tap	1 in each water –closed	1 in each water –closed	1 in each water –closed	1 in each water –closed
iii)	Urinals	Nil up to 6 1 for 7-20 2 for 21-45 3 for 46 - 70 4 for 71-100	–	Nil up to 6 1 for 7-20 2 for 21-45 3 for 46 - 70 4 for 71-100	–
	For persons 101-200 add	3%		3%	
	For persons over 200 add	2.5%		2.5%	
iv)	Washbasins	1 per 25 or part thereof	1 per 25 or part thereof	1 per 25 or part thereof	1 per 25 or part thereof
	Washbasins in rows or troughs and taps spaced 750 mm c/c				
v)	Drinking water fountain	1 per every 100 or part thereof with minimum one on each floor		1 per every 100 or part thereof with minimum one each floor	
vi)	Cleaner's sink	1 on each floor	1 on each floor	1 on each floor	1 on each floor
vii)	Showers/bathing rooms	← As per trade requirements →			
viii)	Emergency shower and eye wash fountain	–	–	1 per every shop floor per 500 persons	

NOTE - For factories requiring workers to be engaged in dirty and dangerous operations or requiring them to being extremely clean and sanitized conditions additional and separate (if required so) toilet facilities and if required by applicable Industrial and Safety laws and the Factories Act must be provided in consultations with the user.

Table 5-3 Cinema, Multiplex Cinema, Concerts and Convention Halls, Theaters

SI No.	Fixtures	Public		Staff	
		Male	Females	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water -Closets	1 per 100 up to 400 Over 400 add at 1 per 250 or part thereof	3 per 100 up to 200 Over 200 add at 2 per 100 or part thereof	1 for up to 15	1 for up to 12
ii)		1 in each water-closet	1 in each water-closet	1 in each water-closet	1 in each water-closet
iii)	Ablution tap	1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals			
iv)	Urinals	1 per 25 or part hereof	–	Nil up to 6 1 for 7-20 2 for 21-45	–
v)	Washbasins	1 per 200 or part thereof		1 for up to 15 2 for 16 -35	1 for up to 12 2 for 13 -25
vi)	Drinking water fountain	← 1 per 100 persons or part thereof →			
vii)	Cleaner's Sink	← 1 per floor →			
viii)	Showers/Bathing rooms	← As per trade requirements →			

NOTES
1. Some WC's may be European style if desired.
2. Male population may be assumed as two third and female population as one-third

Table 5-4 Art Galleries, Libraries and Museums

SI No.	Fixtures	Public		Staff	
		Male	Females	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water -Closets	1 per 200 up to 400 Over 400 add at 1 per 250 or part thereof	1 per 100 up to 200 Over 200 add at 2 per 150 or part thereof	1 for up to 15 2 for 16 – 35	1 for up to 12 2 for 13 -25
ii)	Ablution tap	1 in each water-closet	1 in each water-closet	1 in each water-closet	1 in each water-closet
		I water tap with draining arrangements shall be provided for every 50 persons or part hereof in the vicinity of water – closets and urinals			
iii)	Urinals	1 per 50	–	Nil up to 6 1 for 7-20 2 for 21-45	–
iv)	Washbasins	1 for every 200 or part thereof. For over 400, add at 1 per 250 persons or part thereof	1 for every 200 or part thereof. For over 400, add at 1 per 250 persons or part thereof	1 for up to 15 2 for 16 -35	1 for up to 12 2 for 13 -25
v)	Drinking water fountain	← 1 per 100 persons or part thereof →			
vi)	Cleaner's sink	← 1 per floor *min* →			
vii)	Showers/Bathing rooms	← As per requirements →			

NOTES

1. Some WCs may be European style if desired.
2. Male population may be assumed as two third and female population as one-third

Table 5-5 Hospitals with Indoor Patient Wards

SI No.	Fixtures	Patient Toilets		Staff toilets	
		Male	Females	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i.	Toilet suite comprising one WC and one washbasin and shower stall	Private room with up to 4 patients		For individual doctor's/officer's rooms	
For general Wards, Hospital Staff and Visitors					
i.	Water-closets	1 per 8 beds or part thereof	1 per 8 beds or part thereof	1 for up to 15	1 for up to 12
i.	Ablution tap	One in each water-closets	One in each water-closets	One in each water-closets	One in each water-closets
		I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals			
v.	Urinals	1 per 30 beds	–	Nil up to 6 1 for 7 to 20 2 for 21 -45	–
v.	Washbasins	2 for every 30 beds or part thereof Add 1 per additional 30 beds or part thereof		1 for up to 15 2 for 16 – 35	1 for up to 2 2 for 13 – 25
i.	Drinking water fountain	1 per ward		1 per 100 persons or part thereof	
i.	Cleaner's sink	1 per ward		-	
i.	Bed pan sink	1 per ward		-	
x.	Kitchen sink	1 per ward		-	

NOTES

1. Some WC's may be European style if desired.
2. Male population may be assumed as two-third and female population as one-third.
3. Provisions for additional and special hospital fittings where required shall be made.

Table 5-6 Hospitals Outdoor patient Department

SI No (1)	Fixtures (2)	Patient Toilets: Male (3)	Patient Toilets: Females (4)	Staff toilets: Male (5)	Staff toilets: Female (6)
i)	Toilet Suite comprising one WC and one washbasin (with optional shower stall if building used for 24 hr)	For up to 4 patients		For individual doctor's/officer's rooms	
ii)	Water-closets	1 per100 beds or part thereof	2 per 100 persons or part thereof	1 for up to 15	1 for up to 12
iii)	Ablution tap	One in each water-closets	One in each water-closets	One in each water-closets	One in each water-closets
		I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals			
iv)	Urinals	1 per 50 persons or part thereof	–	Nil up to 6 1 for 7 to 20 2 for 21 -45	–
v)	Washbasins	1 per 100 persons or part thereof	2 per 100 persons or part thereof	1 for up to 15 2 for 16 -35	1 for up to 12 2 for 13 -25
vi)	Drinking water fountain	1 per 500 persons or part thereof		1 per 100 persons or part thereof	

NOTES

1. Some WC's may be European style if desired.
2. Male population may be assumed as two-third and female population as one-third.
3. Provisions for additional and special hospital fittings where required shall be made.

Table 5-7 Hospitals, Administrative Buildings

SI No. (1)	Fixtures (2)	Staff toilets Male (3)	Staff toilets Female (4)
i)	Toilet Suite comprising one WC and one washbasin (with optional shower stall if building used for 24 hr)	for individual doctor's/Officer's rooms	
ii)	Water-closets	1 per25 persons or part thereof	1 per15 persons or part thereof
iii)	Ablution tap	One in each water-closets I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals	One in each water-closets
iv)	Urinals	Nil up to 6 1 for 7 to 20 2 for 21 -45	–
v)	Washbasins	1 per 25 persons or part thereof	1 per 25 persons or part thereof
vi)	Drinking water fountain	1 per 100 persons or part thereof	
vii)	Cleaner's Sink	1 per floor, *Min*	
viii)	Kitchen sink	1 per floor, *Min*	

NOTES- Some WC's may be European style if desired.

Table 5-8 Hospitals staff Quarters and Nurses Homes

SI No (1)	Fixtures (2)	Patient Toilets Male (3)	Patient Toilets Females (4)	Staff toilets Male (5)	Staff toilets Female (6)
i)	Water-closets	1 per 4 persons or part thereof	1 per 4 persons or part thereof	1 per 4 persons or part thereof 2 for 16 -35	1 per 4 persons or part thereof 2 for 13 -25
ii)	Ablution tap	One in each water- closets	One in each water-closets	One in each water-closets	One in each water-closets
		I water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals			
iii)	Washbasin	1 per 8 persons or part thereof		1 per 8 persons or part thereof	
iv)	Bath (Showers)	1 per 4 persons or part thereof		1 per 4 to 6 persons or part thereof	
v)	Drinking water fountain	1 per 100 persons or part thereof Minimum 1 per floor		1 per 100 persons or part thereof, thereof 1 per floor	
vi)	Cleaner's sink	1 per floor		1 per floor	

NOTES

1. Some WC's may be European style if desired.
2. For independent housing units fixtures shall be provided as for residences

Table 5-9 Hotels

SI No (1)	Fixtures (2)	Public Rooms: Male (3)	Public Rooms: Females (4)	Non-Residential Staff: Male (5)	Non-Residential Staff: Female (6)
i)	Toilet Suite comprising one WC , washbasin with shower or a bath tub	Individual guest room with attached to			–
	Guest Rooms with Common Facilities				
ii)	Water-closets	1 per100 persons up to 400 Over 400 add at 1 per 250 or part thereof	2 per 100 persons up to 200 Over 200 add at 1 per 100 or part thereof	1 for up to15 2 for 16 -35 3 for 36 –65 4 fro 66 -100	1 for up to 12 2 for 13 -25 3 for 26 – 40 4 for 41-57 5 for 58 -77 6 for 78 -100
iii)	Ablution tap	One in each water-closets	One in each water-closets	One in each water-closets	One in each water-closets
		I water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals			
iv)	Urinals	1 per 50 persons or part thereof	–	Nil up to 6 1 for 7 to 20 2 for 21 -45 3 for 46 -70 4 for 71 -100	-
v)	Washbasins	1 per WC/Urinal	1 per WC	1 for up to 15 2 for 16-35 3 for 36 -65 4 for 66-100	1 for up to 12 2 for 13 -25 3 for 26 -40 4 for 41-57
vi)	Bath (Showers)	1 per 10 persons or part thereof		-	-
vii)	Cleaner's sink	1 per 30 rooms, minimum 1 per floor			
viii)	Kitchen sink	1 per kitchen			

NOTES

1. Some WC's may be European style if desired.
2. Male population may be assumed as two-third and female population as one-third.
3. Provisions for additional and special hospital fittings where required shall be made.

Table 5-10 Restaurants

SI No	Fixtures	Public Rooms		Non-Residential Staff	
		Male	Females	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water-closets	1 per50 seats up to 200 Over 200 add at 1 per 100 or Part thereof	2 per 50 persons up to 200 Over 200 add at 1 per 100 or Part thereof	1 for up to 15 2 for 16 -35 3 for 36 – 65 4 fro 66 -100	1 for up to 12 2 for 13 -25 3 for 26 – 40 4 for 41-57 5 for 58 -77 6 for 78 -100
ii)	Ablution tap	One in each water-closets	One in each water-closets	One in each water-closets	One in each water-closets
		I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals			
iii)	Urinals	1 per 50 persons or part thereof	-	Nil up to 6 1 for 7 to 20 2 for 21 -45 3 for 46 -70 4 for 71 -100	-
iv)	Washbasins	1 per WC	1 per WC	1 per WC	1 per WC
v)	Cleaner's sink	1 per each restaurant			
vi)	Kitchen sink	1 per kitchen			

NOTES

1. Some WC's may be European style if desired.
2. Male population may be assumed as two-third and female population as one-third.
3. Provisions for additional and special hospital fittings where required shall be made.

Table 5-11 Schools and Educational Institutions

SI. No	Fixtures	Nursery School	Non-Residential Boys	Non-Residential Girls	Residential Boys	Residential Girls
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Water-closets	1 per 15 Pupils or part thereof	1 per 40 pupils or part thereof	1 per 25 pupils or part thereof	1 per 8 pupils or part thereof	1 per 6 pupils or part thereof
ii)	Ablution tap	One in each water - closet	One in each water – closet	One in each water – closet	One in each water - closet	One in each water - closet
		I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals				
iii)	Urinals	–	1 per 20 pupils Or part thereof	–	1 per 25 pupils or Part thereof	-
iv)	Washbasins	1per15 pupils or Part thereof	1 per 60 pupils or part thereof	1 per 40 pupils or part thereof	1 per 8 pupils or part thereof	1 per 6 pupils or part thereof
v)	Bath/Showers	1 per 40 pupils or Part thereof	-	-	1 per 8 pupils or part thereof	1 per 6 pupils or part thereof
vi)	Drinking water fountain or taps	1 per 50 pupils or Part thereof	1 per 50 pupils or part thereof	1 per 50 pupils or part thereof	1 per 50 pupils or part thereof	1 per 50 pupils or part thereof
vii)	Cleaner's sink					

NOTES

1. Some WC's may be European style if desired
2. For teaching staff, the schedule of fixtures to be provided shall be the same as in case of office building.

Table 5-12 Hostels

SI. No	Fixtures	Resident		Non-Residential		Visitor/Common Rooms	
(1)	(2)	Males (3)	Females (4)	Males (5)	Females (6)	Males (7)	Females (8)
i)	Water-closets	1 per 8or part thereof	1 per 6 or part thereof	1 for up to 15 2 for 16 -34 3 for 36 – 65 4 for 66 – 100	1 for up to 12 2 for 13-25 3 for 26 – 40 4 for 41 -57 5 for 58-77 6 for 78 -100	1 per 100 Up to 400 Over 400 add at 1 per 250	2 per 100 Up to 200 Over 200 add at 1 per 100
ii)	Ablution tap	One in each water- closet	One in each water-closet	One in each water-closet	One in each water-closet	One in each water-closet	One in each water-closet
		I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals					
iii)	Urinals	1 per 25 or part thereof	–	Nil up to 6 1 for 7-20 2 for 21 -45 3 for 46 -70 4 for 71-100	–	1 per 50 or part thereof	–
iv)	Washbasins	1 per 8 persons Or part thereof		1 for up to 15 2 for 16 -35 3 for 36 -65 4 for 66 -100	1 for up to 12 2 for 13 -25 3 for 26 – 40 4 for 41 –57 5 for 58 -77 6 for 78 - 100	1 per WC/urinal	1 per WC
v)	Bath/Showers	1 per 8 persons Or part thereof		1 per 8 persons Or part thereof	-	-	-
vi)	Cleaner's sink	**1per each floor**					

NOTES- Some WC's may be European style if desired

Table 5-13 Fruit and Vegetable Markets

Sl. No	Fixtures	Show Owners		Common Toilets in Market Building		Public Toilet Floating Population	
		Males	Females	Males	Females	Males	Females
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Water-closets	1 per 8or part thereof		1 for up to 15 2 for 16 -34 3 for 36 – 65 4 for 66 – 100	1 for up to 12 2 for 13-25 3 for 26 – 40 4 for 41 -57 5 for 58 -77 6 for 78 -100	1 per 50 (Minimum 2)	1 per 50 (Minimum 2)
ii)	Ablution tap	One in each water- closet		One in each water- closet	One in each water- closet	One in each water- closet	One in each water- closet
		I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals					
iii)	Urinals	–	–	Nil up to 6 1 for 7-20 2 for 21 -45 3 for 46 -70 4 for 71-100	-	1 per 50	-
iv)	Washbasins	1 per 8 persons or part thereof		1 for up to 15 1 for up to 12 2 for 16 -35 3 for 36 -65 4 for 66 -100	1 for upto 12 2 for 13-25 3 for 26-40 4 for 41-57	-	-
v)	Bath/Showers	1 per 8 persons or part thereof	1 per 6 persons or part thereof	-	-	1 per 50 persons	1 per 50 persons

NOTES

1. Toilet facilities for individual buildings in a market should be taken some as that for office buildings.
2. Common toilets in the market buildings provide facilities for persons working in shops and their regular visions.
3. Special toilet facilities for a large floating population of out of town buyers/sellers., labor, drivers of vehicles for whom special toilet (public toilets)

Table 5-14 Airports and Railway Stations

Sl. No	Fixtures	Junctions Stations, Intermediate Stations and Bus Stations		Terminal Railway and Bus Stations		Domestic and International Airports	
		Males	Females	Males	Females	Males	Females
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(i)	Water-closets	3 for up to 1000 add 1 per additional 1000 or part thereof	4 for up to 1000 add 1 per additional 1000 or part thereof	4 for up to 1000 add 1 per additional 1000 or part thereof	5 for up to 1000 Add 1 per Additional 1000 Or part thereof	Minimum 2 For 200 5 For 400 9 For 600 12 For 800 16 For 1000 18	Minimum 2 For 200 5 For 400 9 For 600 12 For 800 16 For 1000 18
(ii)	Ablution tap	One in each water-closet	One in each water-closet	One in each water-closet	One in each water-closet	One in each water-closet	
		I water tap wit draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water –closets and urinals					
(iii)	Urinals	4 for up to 100 add 1 per additional 1000	-	6 for up to 1000 add 1 per additional 1000	-	1 per 40 or part thereof	-
(iv)	Washbasins	1 per WC/Urinal	1 per WC	1 per WC/Urinal	1 per WC	1 per WC/Urinal	1 per WC
(v)	Bath/Showers	2 per 1000		3 per 1000		4 per 1000	
(vi)	Drinking water fountain or taps (in common lobby for male/female)	2 per 1000 or part thereof		3 per 1000 or part thereof		4 per 1000 or part thereof	
(vii)	Cleaner's sink	1 per toilet compartment with WC's	1 per toilet compartment with WC's	1 per toilet compartment with WC's	1 per toilet compartment with WC's	1 per toilet compartment with WC's	1 per toilet compartment with WC's
(viii)	Toilet for disabled	1 per 4000	1 per 4000	1 per 4000	1 per 4000	1 per 4000	1 per 4000

NOTES

1. Some WC's may be European style if desired
2. Male population may be assumed as there-fifth and female population as two fifth
3. Separate provision shall be made for staff and workers.

5.3.4 Number of Occupants of Each Sex

The required water closets, lavatories, and showers or bathtubs shall be distributed equally between the sexes based on the percentage of each sex anticipated in the occupant load. The occupant load shall be composed of 50 percent of each sex, unless statistical data indicate a different distribution of the sexes.

5.3.5 Installation of Fixtures

5.3.5.1 Water supply protection

The supply lines and fittings for every plumbing fixture shall be installed so as to prevent backflow.

5.3.5.2 Access for cleaning

Plumbing fixtures shall be installed so as to afford easy access for cleaning both the fixture and the area around the fixture.

5.3.5.3 Setting

Fixtures shall be set level and in proper alignment with reference to adjacent walls. Water closets, urinals, lavatories and bidets. A water closet, urinal, lavatory or bidet shall not be set closer than 15 inches (381 mm) from its center to any side wall, partition, vanity or other obstruction, or closer than 30 inches (762 mm) center-to-center between adjacent fixtures. There shall be at least a 21-inch (533 mm) clearance in front of the water closet, urinal, lavatory or bidet to any wall, fixture or door. Water closet compartments shall not be less than 30 inches (762mm) wide and 60 inches (1524 mm) deep.(**see Figure 5.1)**

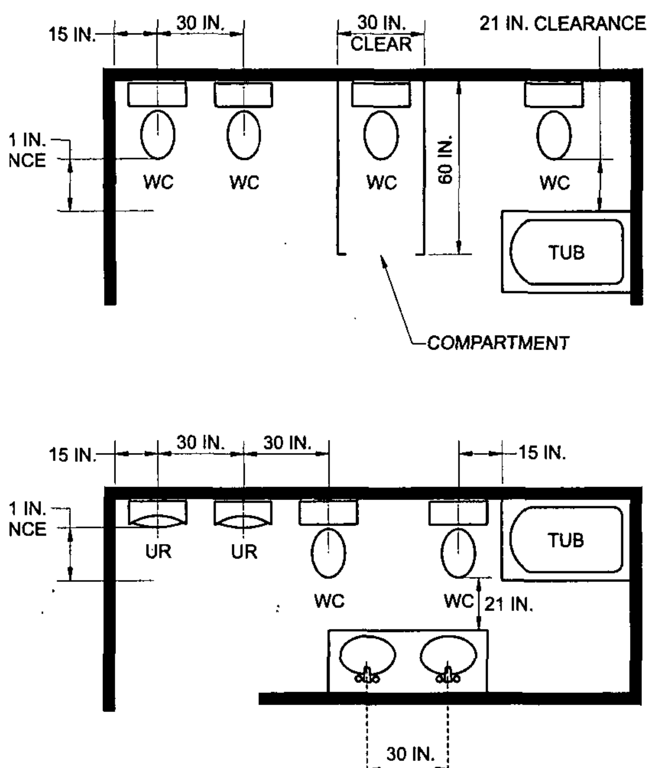


Figure 5-1 Fixture Clearances

5.3.5.4 Floor and wall drainage connections

Connections between the drain and floor outlet plumbing fixtures shall be made with a floor flange. The flange shall be attached to the drain and anchored to the structure. Connections between the drain and wall-hung water closets shall be made with an approved extension nipple or home adaptor. The water closet shall be bolted to the hanger with corrosion-resistant bolts or screws. Joints shall be sealed with an approved elastomeric gasket, flange-to-fixture connection complying with or an approved setting compound.

Floor flanges for water closets or similar fixtures shall not be less than 0.125inch (3.2 mm) thick for brass, 0.25 inch (6.4 mm) thick for plastic, and 0.25inch (6.4mm) thick and not less than a 2-inch (51 mm) caulking depth for cast-iron or galvanized malleable iron.

Floor flanges of hard lead shall weigh not less than 1 pound, 9 ounces (0.7 kg) and shall be composed of lead alloy with not less than 7.75-percent antimony by weight. Closet screws and bolts shall be of brass. Flanges shall be secured to the building structure with corrosion-resistant screws or bolts.

5.3.5.5 Design of overflows

Where any fixture is provided with an overflow, the waste shall be designed and installed so that standing water in the fixture will not rise in the overflow when the stopper is closed, and no water will remain in the overflow when the fixture is empty.

The overflow from any fixture shall discharge into the drainage system on the inlet or fixture side of the trap.

5.3.6 Drainage Piping Installation

5.3.6.1 Slope of horizontal drainage piping

Horizontal drainage piping shall be installed in uniform alignment at uniform slopes. The minimum slope of a horizontal drainage pipe shall be in accordance with Table5.15.

Table 5-15 Slope of Horizontal Drainage Pipe

Size(Inches)	Minimum Slope (Inch per foot)
2 ½ or less	1/4
3 to 6	1/8
8 or larger	1/16

5.3.6.2 Change in size

The size of the drainage piping shall not be reduced in size in the direction of the flow. A 4-inch by 3-inch (102 mm by 76 mm) water closet connection shall not be considered as a reduction in size.

5.3.6.3 Connections to offsets and bases of stacks

Horizontal branches shall connect to the bases of stacks at a point located not less than 10 times the diameter of the drainage stack downstream from the stack.

5.3.6.4 Future fixtures

Drainage piping for future fixtures shall terminate with an approved cap or plug.

5.3.6.5 Dead Ends

In the installation or removal of any part of a drainage system, dead ends shall be prohibited. Cleanout extensions and approved future fixture drainage piping shall not be considered as dead ends.

5.4 Materials, Fittings and Appliances

5.4.1 Standards for Materials, Fittings and Sanitary Appliances

All materials, fittings and sanitary appliances shall conform to 'Building Materials' requirements or acceptable standards.

5.4.2 Choice of Material for Pipes

5.4.2.1 Cast iron pipes

(1) These pipes shall be used in the following situation:
- a) under buildings and where pipes are suspended in basements and like situations;
- b) in reaches where the velocity is more than 2.4 m/s; and

(2) Cast iron pipes shall conform to accepted standards.

5.4.2.2 Asbestos cement pipes

Asbestos cement pipes are commonly used for house drainage systems and they shall conform to accepted standards . Where so desired, the life of asbestos cement pipes may be increased by lining inside of the pipe with suitable coatings like epoxy/polyester resins etc.

5.4.2.3 PVC pipes

Unplasticized PVC pipes may be used for drainage purposes; however, where hot water discharge is anticipated, the wall thickness shall be minimum 3 mm irrespective of the size and flow load.

PVC and HDPE pipes shall conform to accepted standards.

Note:- Where possible, high density polyethylene pipes (HDPE) and PVC pipes may be used for drainage and sanitation purposes, depending upon the suitability.

5.4.3 Quality of Fixtures

Plumbing fixtures shall be constructed of approved materials, with smooth, impervious surfaces, free from defects and concealed fouling surfaces, and shall conform to accepted standards. All porcelain enameled surfaces on plumbing fixtures shall be acid resistant.

5.4.4 Connections between Drainage Piping and Fittings

5.4.4.1 Connections and changes in direction

All connections and changes in direction of the sanitary drainage system shall be made with approved drainage fittings. Connections between drainage piping and fixtures shall conform to 5.3.8.

5.4.4.2 Obstructions

The fittings shall not have ledges, shoulders or reductions capable of retarding or obstructing flow in the piping. Threaded drainage pipe fittings shall be of the recessed drainage type.

5.4.4.3 Installation of fittings

Fittings shall be installed to guide sewage and waste in the direction of flow. Change in direction shall be made by fittings installed in accordance with Table 5.16. Change in direction by combination fittings, side inlets or increasers shall be installed in accordance with Table 5.16 based on the pattern of flow created by the fitting.

Table 5-16 Fitting for Change in Direction

Type of Fitting Pattern	Change in Direction		
	Horizontal to vertical	**Vertical to horizontal**	**Horizontal to horizontal**
Sixteenth bend	X	X	X
Eighth bend	X	X	X
Sixth bend	X	X	X
Quarter bend	X	X[a]	X[a]
Short Sweep	X	X[a,b]	X[a]
Long Sweep	X	X	X
Sanitary tee	X[c]	-	-
Wye	X	X	X
Combination wye and eighth bend	X	X	X

For SI: 1 inch = 25.4 mm.
a. The fittings shall only be permitted for a 2 –inch or smaller fixture drain
b. There inches or larger.
c. For a limitation double sanitary tees, see section 5.4.4.3

5.4.4.4 Heel- or side-inlet quarter bends

Heel-inlet quarter bends shall be an acceptable means of connection, except where the quarter bend serves a water closet. A low-heel inlet shall not be used as a wet-vented connection. Side-inlet quarter bends shall be an acceptable means of connection for drainage, wet venting and stack venting arrangements.

5.4.5 Cleanouts

5.4.5.1 Scope

This section shall govern the size, location, installation and maintenance of drainage pipe cleanouts .

5.4.5.2 Cleanout plugs

Cleanout plugs shall be brass or plastic, or other approved materials. Brass cleanout plugs shall be utilized with metallic drain, waste and vent piping only, Cleanouts with plate-style access covers shall be fitted with corrosion-resisting fasteners. Plastic cleanout plugs shall conform to the requirements. Plugs shall have raised square or countersunk square heads. Countersunk heads shall be installed where raised heads are a trip hazard. Cleanout plugs with borosilicate glass systems shall be of borosilicate glass.

5.4.5.3 Where required

Cleanouts shall be located in accordance with sections 5.4.5.3.1 through 5.4.5.3.3.

5.4.5.3.1 Horizontal drains within buildings

All horizontal drains shall be provided with cleanouts located not more than 100 feet (30 480 mm) apart.

5.4.5.3.2 Changes of direction

Cleanouts shall be installed at each change of direction greater than 45 degrees (0.79 rad) in the building drain and horizontal waste or soil lines. Where more than one change of direction occurs in a run of piping, only one cleanout shall be required for each 40 feet (12 192 mm) of developed length of the drainage piping.

5.4.5.3.3 Base of stack

A cleanout shall be provided at the base of each waste or soil stack.

5.4.5.4 Concealed piping

Cleanouts on concealed piping or piping under a floor slab or in a crawl space of less than 24 inches (610 mm) in height or a plenum shall be extended through and terminate flush with the finished wall, floor or ground surface or shall be extended to the outside of the building.

5.4.5.5 Opening direction

Every cleanout shall be installed to open to allow cleaning in the direction of the flow of the drainage pipe or at right angles thereto.

5.4.5.6 Minimum size

Cleanouts shall be the same nominal size as the pipe they serve up to 4 inches (102 mm). For pipes larger than 4 inches (102 mm) nominal size, the minimum size of the cleanout shall be 4 inches (102 mm).

5.4.5.7 Clearances

Cleanouts on 6-inch (153 mm) and smaller pipes shall be provided with a clearance of not less than18 inches (457 mm) for rodding. Cleanouts on 8-inch (203 mm) and larger pipes shall be provided with a clearance of not less than 36 inches (914 mm) for rodding.

5.4.5.8 Access

Access shall be provided to all cleanouts.

5.5 Vents

5.5.1 General

5.5.1.1 Scope

The provisions of this section shall govern the materials, design, construction and installation of vent systems.

5.5.1.2 Trap seal protection

The plumbing system shall be provided with a system of vent piping that will permit the admission or emission of air so that the seal of any fixture trap shall not be subjected to a pneumatic pressure differential of more than 1 inch of water column (249 Pa).

5.5.1.2.1 Venting required

Every trap and trapped fixture shall be vented in accordance with one of the venting methods specified in this section.

5.5.1.3 Chemical waste vent system

The vent system for a chemical waste system shall be independent of the sanitary vent system and shall terminate separately through the roof to the open air.

5.5.1.4 Use limitations

The plumbing vent system shall not be utilized for purposes other than the venting of the plumbing system.

5.5.1.5 Tests

The vent system shall be tested in accordance with accepted standard.

5.5.1.6 Engineered systems

Engineered venting systems shall conform to the provisions of Section 5.5.18.

5.5.2 Materials

5.5.2.1 Vents

The materials and methods utilized for the construction and installation of venting systems shall comply with acceptable standards.

5.5.2.2 Sheet copper

Sheet copper for vent pipe flashings shall conform to accepted standards and shall weigh not less than 8 ounces per square foot (2.5 kg/m2).

5.5.2.3 Sheet lead

Sheet lead for vent pipe flashings shall weigh not less than 3 pounds per square foot (15 kg/m^2) for field-constructed flashings and not less than 2.5 pounds per square foot (12 kg/m^2) for prefabricated flashings.

5.5.3 Outdoor Vent Extension

5.5.3.1 Required vent extension

The vent system serving each building drain shall have at least one vent pipe that extends to the outdoors.

5.5.3.1.1 Installation

The required vent shall be a dry vent that connects to the building drain or an extension of a drain that connects to the building drain.

5.5.3.1.2 Size

The required vent shall be sized in accordance with Section 5.5.16.2 based on the required size of the building drain.

5.5.3.2 Vent stack required

A vent stack shall be required for every drainage stack that has five branch intervals or more.

5.5.3.3 Vent termination

Every vent stack or stack vent shall terminate outdoors to the open air or to a stack-type air admittance valve in accordance with Section 5.5.17.

5.5.3.4 Vent connection at base

Every vent stack shall connect to the base of the drainage stack. The vent stack shall connect at or below the lowest horizontal branch. Where the vent stack connects to the building drain, the connection shall be located downstream of the drainage stack and within a distance of 10 times the diameter of the drainage stack.

5.5.3.5 Vent headers

Stack vents and vent stacks connected into a common vent header at the top of the stacks and extending to the open air at one point shall be sized in accordance with the requirements of Section 5.5.16.1. The number of fixture units shall be the sum of all fixture units on all stacks connected thereto, and the developed length shall be the longest vent length from the intersection at the base of the most distant stack to the vent terminal in the open air, as a direct extension of one stack.

5.5.4 Vent Terminals

5.5.4.1 Roof extension

All open vent pipes that extend through a roof shall be terminated at least at least 7 feet (2134 mm) above the roof.

5.5.4.2 Flashings

The juncture of each vent pipe with the roof line shall be made water tight by an approved flashing.

5.5.4.3 Location of vent terminal

An open vent terminal from a drainage system shall not be located directly beneath any door, open able window, or other air intake opening of the
building or of an adjacent building, and any such vent terminal shall not be within 10 feet (3048 mm) horizontally of such an opening unless it is at least 2 feet (610 mm) above the top of such opening.

5.5.4.4 Extension through the wall

Vent terminals extending through the wall shall terminate a minimum of 10 feet (3048mm) from the lot line and 10 feet (3048 mm) above average ground level. Vent terminals shall not terminate under the overhang of a structure with soffit vents. Side wall vent terminals shall be protected to prevent birds or rodents from entering or blocking the vent opening.

5.5.5 Vent Connections and Grades

5.5.5.1 Connection

All individual, branch and circuit vents shall connect to a vent stack, stack vent, air admittance valve or extend to the open air.

5.5.5.2 Grade

All vent and branch vent pipes shall be so graded and connected as to drain back to the drainage pipe by gravity.

5.5.5.3 Vent connection to drainage system

Every dry vent connecting to a horizontal drain shall connect above the centerline of the horizontal drain pipe;

5.5.5.4 Vertical rise of vent

Every dry vent shall rise vertically to a minimum of 6 inches (152mm) above the flood level rim of the highest trap or trapped fixture being vented.

5.5.5.5 Height above fixtures

A connection between a vent pipe and a vent stack or stack vent shall be made at least 6 inches (152 mm) above the flood level rim of the highest fixture served by the vent. Horizontal vent pipes forming branch vents, relief vents or loop vents shall be at least 6 inches (152 mm) above the flood level rim of the highest fixture served.

5.5.5.6 Vent for future fixtures

Where the drainage piping has been roughed-in for future fixtures, a rough-in connection for a vent shall be installed. The vent size shall be not less than one half the diameter of the rough-in drain to be served. The vent rough-in shall connect to the vent system, or shall be vented by other means as provided for in this section. The connection shall be identified to indicate that it is a vent.

5.5.6 Fixture Vents

5.5.6.1 Distance of trap from vent

Each fixture trap shall have a protecting vent located so that the slope and the developed length in the fixture drain from the trap weir to the vent fitting are within the requirements set forth in Table 5.17.

Table 5-17 Maximum Distance of Fixture Trap from Vent

Size of Trap	Slope (Inch per foot)	Distance from trap (feet)
1 ¼	1/4	5
1 ½	1/4	6
2	1/4	8
3	1/8	12
4	1/8	16
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm; 1 inch per foot = 83.3 mm/m.		

5.5.6.2 Venting of fixture drains

The total fall in a fixture drain due to pipe slope shall not exceed the diameter of the fixture drain.

5.5.6.3 Crown Vent.

A vent shall not be installed within two pipe diameters of the trap weir.

5.5.7 Individual Vent

5.5.7.1 Individual vent permitted

Each trap and trapped fixture is permitted to be provided with an individual vent. The individual vent shall connect to the fixture drain of the trap or trapped fixture being vented.

5.5.8 Common Vent

5.5.8.1 Individual vent as common vent

An individual vent is permitted to vent two traps or trapped fixtures as a common vent. The traps or trapped fixtures being common vented shall be located on the same floor level.

5.5.8.2 Connection at the same level

Where the fixture drains being common vented connect at the same level, the vent connection shall be at the interconnection of the fixture drains at different levels, the vent shall connect as a vertical extension of the vertical drain. The vertical drain pipe connecting the two fixture drains shall be considered the vent for the lower fixture drain, and shall be sized in accordance with Table 5.18. The upper fixture shall not be a water closet.

Table 5-18 Common Vent Sizes

Pipe Size (Inches)	Maximum Discharge from Upper Fixture drain (dfu)
1 ½	1
2	4
2 ½ to 3	6
For SI: 1 inch = 25.4 mm.	

5.5.9 Wet Venting

5.5.9.1 Horizontal wet vent permitted

Any combination of fixtures within two bathroom groups located on the same floor level is permitted to be vented by a horizontal wet vent. The wet vent shall be considered the vent for the fixtures and shall extend from the connection of the dry vent along the direction of the flow in the drain pipe to. The most downstream fixture drain connection to the horizontal branch drain. Only the fixtures within the bathroom groups shall connect to the wet vented horizontal branch drain. Any additional fixtures shall discharge downstream of the horizontal wet vent.

5.5.9.1.1 Vertical wet vent permitted

Any combination of fixtures within two bathroom groups located on the same floor level is permitted to be vented by a vertical wet vent. The vertical wet vent shall be considered the vent for the fixtures and shall extend from the connection of the dry vent down to the lowest fixture drain connection. Each wet-vented fixture shall connect independently to the vertical wet vent. Water closet drains shall connect at the same elevation. Other fixture drains shall connect above or at the same elevation as the water closet fixture drains. The dry vent connection to the vertical wet vent shall be an individual or common vent serving one or two fixtures.

5.5.9.2 Vent connection

The dry-vent connection to the wet vent shall be an individual vent or common vent to the lavatory, bidet; shower or bathtub. In vertical wet-vent systems, the most upstream fixture drain connection shall be a dry-vented fixture drain connection. In horizontal wet-vent systems, not more than one wet-vented fixture drain shall discharge upstream of the dry-vented fixture drain connection.

5.5.9.3 Size

The dry vent serving the wet vent shall be sized based on the largest required diameter of pipe within the wet vent system served by the dry vent. The wet vent shall be of a minimum size as specified in Table 5.19, based on the fixture unit discharge to the wet vent.

Table 5-19 Wet Vent Size

Wet Vent Pipe size (Inches)	Drainage Fixture Unit Load (dfu)
1 ½	1
2	4
2 ½	6
3	12
For SI: 1 inch = 25. 4 mm.	

5.5.10 Waste Stack Vent

5.5.10.1 Waste stack vent permitted

A waste stack shall be considered a vent for all of the fixtures discharging to the stack where installed in accordance with the requirements of this section.

5.5.10.2 Stack installation

The waste stack shall be vertical, and both horizontal and vertical offsets shall be prohibited between the lowest fixture drain connection and the highest fixture drain connection. Every fixture drain shall connect separately to the waste stack.

5.5.10.3 Stack vent

A stack vent shall be provided for the waste stack. The size of the stack vent shall be not less than the size of • the waste stack. Offsets shall be permitted in the stack vent shall be located at least 6 inches (152 mm) above the flood level of the highest fixture and shall be in accordance with Section 5.5.5.5. The stack vent shall be permitted to connect with other stack vents and vent stacks in accordance with Section 5.5.3.5.

5.5.10.4 Waste stack size

The waste stack shall be sized based on the total discharge to the stack and the discharge within a branch interval in accordance with Table 5.20. The waste stack shall be the same size throughout its length.

Table 5-20 Waste Stack Vent Size

Stack Size (Inches)	Maximum Number of Drainage Fixture Units (dfu)		
	Total Discharge		Total Discharge

	into one branch interval	**for stack**
1 ½	1	2
2	2	4
2 ½	No limit	8
3	No limit	24
4	No limit	50
5	No limit	75
6	No limit	100
For SI: 1 inch = 25. 4 mm.		

5.5.11 Circuit Venting

5.5.11.1 Circuit vent Permitted

A maximum of eight fixtures connected to a horizontal branch drain shall be permitted to be circuit vented. Each fixture drain shall connect horizontally to the horizontal branch being circuit vented.

5.5.11.1.1 Multiple circuit-vented branches

Circuit-vented horizontal branch drains are permitted to be connected together. Each group of a maximum of eight fixtures shall be considered a separate circuit vent and shall conform to the requirements of this section.

5.5.11.2 Vent Connection

The circuit vent connection shall be located between the two most upstream fixture drains. The vent shall connect to the horizontal branch and shall be installed in accordance with Section 5.5.5.

5.5.11.3 Slope And Size Of Horizontal Branch

The maximum slope of the vent section of the horizontal branch drain shall be one unit vertical in 12 units horizontal (8-percent slope). The entire length of the vent section of the horizontal branch drain shall be sized for the total drainage discharge to the branch.

5.5.11.3.1 Size of multiple circuit vent

Each separate circuit-vented horizontal branch that is interconnected shall be sized independently in accordance with Section 5.5.11.3. The downstream circuit-vented horizontal branch shall be sized for the total discharge into the branch, including the upstream branches and the fixtures within the branch.

5.5.11.4 Relief vent

A relief vent shall be provided for circuit vented horizontal branches receiving the discharge of four or more water closets and connecting to a drainage stack that receives the discharge of soil or waste from upper horizontal branches.

5.5.11.4.1 Connection and installation

The relief vent shall connect to the horizontal branch drain between the stack and the most downstream fixture drain of the circuit vent. The Relief vent shall be installed in accordance with Section 5.5.5.

5.5.11.4.2 Fixture drain or branch

The relief vent is permitted to be a fixture drain or fixture branch for fixtures located within the same branch interval as the circuit-vented horizontal branch. The maximum discharge to a relief vent shall be four fixture units.

5.5.11.5 Additional fixtures

Fixtures, other than the circuit- vented fixtures, are permitted to discharge to the horizontal branch drain. Such fixtures shall be located on the same floor as the circuit-vented fixtures and shall be either individually or common vented.

5.5.12 Combination Drain and Vent System

5.5.12.1 Type of fixtures

A combination drain and vent system shall not serve fixtures other than floor drains, sinks, lavatories and drinking fountains.

5.5.12.2 Installation

The only vertical pipe of a combination I drain and vent system shall be the connection between the fixture drain and the horizontal combination drain and vent pipe.
The maximum vertical distance shall be 8 feet (2438 mm).

5.5.12.2.1 Slope

The horizontal combination drain and vent pipe shall have a maximum slope of one-half unit vertical in 12 units horizontal (4-percent slope). The minimum slope shall be in accordance with Table 5.15.

5.5.12.2.2 Connection

The combination drain and vent system shall be provided with a dry vent connected at any point within the system or the system shall connect to a horizontal drain that is vented in accordance with one of the venting methods specified in this chapter. Combination drain and vent systems connecting to building drains receiving only the discharge from a stack or stacks shall be provided with a dry vent. The vent connection to the combination drain and vent pipe shall extend vertically a minimum of6 inches (152mm) above the flood level rim of the highest fixture being vented before offsetting horizontally.

5.5.12.2.3 Vent size

The vent shall be sized for the total drainage fixture unit load in accordance with Section 5.5.16.2.

5.5.12.2.4 Fixture branch or drain

The fixture branch or fixture drain shall connect to the combination drain and vent within a distance specified in Table 5.17. The combination drain and vent pipe shall be considered the vent for the fixture.

5.5.13 Island Fixture Venting

5.5.13.1 Limitation

Island fixture venting shall not be permitted for fixtures other than sinks and lavatories. Residential kitchen sinks with a dishwasher waste connection, a food waste grinder, or both, in combination with the kitchen sink waste, shall be permitted to be vented in accordance with this section.

5.5.13.2 Vent Connection

The island fixture vent shall connect to the fixture drain as required for an individual or common vent. The vent shall rise vertically to above the drainage outlet of the fixture being vented before offsetting horizontally or vertically downward. The vent or branch vent for multiple island fixture vents shall extend to a minimum of 6 inches (152 mm) above the highest island fixture being vented before connecting to the outside vent terminal

5.5.13.3 Vent installation below the fixture flood level rim

The vent located below the flood level rim of the fixture being vented shall be installed as required for drainage piping in accordance with this section, except for sizing. The vent shall be sized in accordance with Section 5.5.16.2. The lowest point of the island fixture vent shall connect full size to the drainage system. The connection shall be to a vertical drain pipe or to the top half of a horizontal drain pipe. Cleanouts shall be provided in the island fixture vent to permit rodding of all vent piping located below the flood level rim of the fixtures. Rodding in both directions shall be permitted through a cleanout.

5.5.14 Relief Vents-Stacks of More Than 10 Branch Intervals

5.5.14.1 Where required

Soil and waste stacks in buildings having more than 10 branch intervals shall be provided with a relief vent at each tenth interval installed, beginning with the top floor.

5.5.14.2 Size and connection

The size of the relief vent shall be equal to the size of the vent stack to which it connects. The lower end of each relief vent shall connect to the soil or waste stack through a wye below the horizontal branch serving the floor, and the upper end shall connect to the vent stack through a wye not less than 3 feet (914 mm) above the floor.

5.5.15 Vents For Stack Offsets

5.5.15.1 Vent for horizontal offset of drainage stack

Horizontal offsets of drainage stacks shall be vented where five or more branch intervals are located above the offset. The offset shall be vented by venting the upper section of the drainage stack and the lower section of the drainage stack.

5.5.15.2 Upper section

The upper section of the drainage stack shall be vented as a separate stack with a vent stack connection installed in accordance with Section 5.5.3.4. The offset shall be considered the base of the stack.

5.5.15.3 Lower section

The lower section of the drainage stack shall be vented by a yoke vent connecting between the offset and the next lower horizontal branch. The yoke vent connection shall be permitted to be a vertical extension of the drainage stack. The size of the yoke vent and connection shall be a minimum of the size required for the vent stack of the drainage stack.

5.5.16 Vent Pipe Sizing

5.5.16.1 Size of stack vents and vent stacks

The minimum required diameter of stack vents and vent stacks shall be determined from the· developed length and the total of drainage fixture units connected thereto in accordance with Table 5.21, but in no case shall the diameter be less than one-half the diameter of the drain served or less than 11/ 4 inches (32 mm).

Table 5-21 Sizes and Developed Length of Stack Vents and Vent Stacks

Diameter of Soil or Wastes Stack (inches)	Total fixture Units Being Vented (dfu)	Maximum Developed Length of Vent (feet)[a] Diameter of Vent (Inches)										
		1 ¼	1 ½	2	2 ½	3	4	5	6	8	10	12
1 ¼	2	30										
1 ½	8	50	150	-	-	-	-	-	-	-	-	-
1 ½	10	30	100									
2	12	30	75	200								
2	20	26	50	150		-	-	-	-	-	-	-
2 ½	42		30	100	300							
3	10		42	150	360	1,040						
3	21	-	32	110	270	810	-	-	-	-	-	-
3	53		27	94	230	680						
3	102		25	86	210	620						
4	43	-		35	85	250	980	-	-	-	-	-
4	140			27	65	200	750					
4	320			23	55	170	640					
4	540	-	-	21	50	150	580		-	-	-	-
5	190				28	82	320	990				
5	490				21	63	250	760				
5	940	-	-	-	18	53	210	670	-	-	-	-
5	1,400				16	49	190	590				
6	500					33	130	400	1000			
6	1,100	-	-	-	-	26	100	310	780	-	-	-
6	2,000					22	84	260	660			
6	2,900					20	77	240	600			
8	1,800	-	-	-	-		31	95	240	940	-	-
8	3,400						24	73	190	720		
8	5,600						20	62	160	610		
8	7,600	-	-	-	-	-	18	56	140	560		-
10	4,000							31	78	310	960	
10	7,200							24	60	240	740	
10	11,000	-	-	-	-	-	-	20	51	200	630	-
10	15,000							18	46	180	570	
12	7,300								31	120	380	940
12	13,000	-	-	-	-	-	-	-	24	94	300	720
12	20,00								20	79	250	610
12	26,000								18	72	230	500
15	15,000	-	-	-	-	-	-	-		40	130	310
15	25,000									31	96	240
15	38,000									26	81	200
15	50,000	-	-	-	-	-	-	-	-	24	74	180

For SI 1 inch=25.4mm, 1 foot = 304.8mm

a) The developed length shall be measured from the event connection to the open air

5.5.16.2 Vents other than stack vents or vent stacks

The diameter of individual vents, branch vents, circuit vents and relief vents shall be at least one-half the required diameter of the drain served. The required size of the drain shall be determined in accordance with Table 5.22. Vent pipes shall not be less than 11/ 4 inches (32 mm) in diameter. Vents exceeding 40 feet (12192mm) in developed length shall be increased by one nominal pipe size for the entire developed length of the vent pipe. Relief vents for soil and waste stacks in buildings having more than 10 branch intervals shall be sized in accordance with Section 5.5.14.2.

Table 5-22 Horizontal Fixture Branches and Stacks

Diameter of Pipe (Inches)	Maximum Number of Drainage Fixture Units(dfu)			
	Total for horizontal branch	Total discharge into one branch interval	Total for stack of three branch intervals or less	Total for stack greater than three branch intervals
1 ½	3	2	4	8
2	6	6	10	24
2 ½	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1100
6	620	350	960	1900
8	1400	600	2,200	3600
10	2500	1000	3,800	5600
12	2900	1500	6000	8400
15	7000	Note c	Note c	Note c

For SI: 1 inch = 25.4 mm

a. Does not include branches of the building drain. Refer to Table 5.25

b. Stacks shall be sized based on the total accumulated connected load at each story or branch interval. As the total accumulated connected load decreases, stacks are permitted to be reduced in size. Stack diameters shall not be reduced to less than one –half of the diameters of the largest stack size required.

c. Sizing load based on design criteria

5.5.16.3 Developed length

The developed length of individual, branch, circuit and relief vents shall be measured from the farthest point of vent connection to the drainage system to the point of connection to the vent stack, stack vent or termination outside of the building.

5.5.16.4 Multiple branch vents

Where multiple branch vents are connected to a common branch vent, the common branch vent shall be sized in accordance with this section based on the size of the common horizontal drainage branch that is or would be required to serve the total drainage fixture unit (dfu) load being vented.

5.5.16.4.1 Branch vents exceeding 40 feet in developed length

Branch vents exceeding 40 feet (12 192 mm) in developed length shall be increased by one nominal size for the entire developed length of the vent pipe.

5.5.17 Air Admittance Valves

5.5.17.1 General

Vent systems utilizing air admittance valves shall comply with this section. Stack-type air admittance valves shall conform to accepted standards. Individual and branch-type air admittance valves shall conform to accepted standards.

5.5.17.2 Installation

The valves shall be installed in accordance with the requirements of this section and the manufacturer's installation instructions.

5.5.17.3 Where permitted

Individual, branch and circuit vents shall be permitted to terminate with a connection to an individual or branch-type air admittance valve. Stack vents and vent stacks shall be permitted to terminate to stack-type air admittance valves. Individual and branch-type air admittance valves shall vent only fixtures that are on the same floor level and connect to a horizontal branch drain. The horizontal branch drain having individual and branch-type air admittance valves shall conform to Section 5.5.17.3.1 or 5.5.17.3.2. Stack-type air admittance valves shall conform to Section 5.5.17.3.3.

5.5.17.3.1 Location of branch

The horizontal branch drain shall connect to the drainage stack or building drain a maximum of four branch intervals from the top of the stack.

5.5.17.3.2 Relief vent

Where the horizontal branch is located I more than four branch intervals from the top of the stack, the horizontal branch shall be provided with a relief vent that shall connect to a vent stack or stack vent, or extend outdoors to the open air. The relief vent shall connect to the horizontal branch drain between the stack and the most downstream fixture drain connected to the horizontal branch drain. The relief pipe shall be sized to relieve air pressure inside the ejector to atmospheric pressure, but shall not be less than 11/ 4 inches (32 mm) in size. The relief vent shall be permitted to serve as the vent for other fixtures

5.5.17.3.3 Stack

Stack-type air admittance valves shall not serve as the vent terminal for vent stacks or stack vents that serve drainage stacks exceeding six branch intervals.

5.5.17.4 Location

Individual and branch-type air admittance valves shall be located a minimum of 4 inches (102 mm) above the horizontal branch drain or fixture drain being vented. Stack-type air admittance valves shall be located not less than 6 inches (152 mm) above the flood level rim of the highest fixture being vented. The air admittance valve shall be located within the maximum developed length permitted for the vent. The air admittance valve shall be installed a minimum of 6 inches (152mm) above insulation materials.

5.5.17.5 Access and ventilation

Access shall be provided to all air admittance valves. The valve shall be located within a ventilated space that allows air to enter the valve.

5.5.17.6 Size

The air admittance valve shall be rated in accordance with the standard for the size of the vent to which the valve is connected.

5.5.17.7 Vent required

Within each plumbing system, a minimum of one stack vent or vent stack shall extend outdoors to the open air.

5.5.18 Engineered Vent Systems

5.5.18.1 General

Engineered vent systems shall comply with this section for the design, submittal, approval, inspection and testing requirements

5.5.18.2 Individual branch fixture and individual fixture header vents

The maximum developed length of individual fixture vents to vent branches and vent headers shall be determined in accordance with Table 5.23 for the minimum pipe diameters at the indicated vent airflow rates.

The individual vent airflow rate shall be determined in accordance with the following:

$$Qh,b = Nn,b\ Qv$$

For SI: $Qh,b = Nn,b\ Qv$ (0.4719 L/s)

Where:
Nn,b = Number of fixtures per header (or vent branch) + total number of fixtures connected to vent stack.

Qh,b =Vent branch or vent header airflow rate (cfm).

Qv = Total vent stack airflow rate (cfm).

Qv (gpm) =27.8 rs2/3 (1 - rs) D8/3

Qv (cfm) =0.134 Qv(gpm)

Where:
D = Drainage stack diameter (inches).

Qw = Design discharge load (gpm).

rs = Waste water flow area to total area.
= Qw/27.8*) D8/3*

Individual vent airflow rates are obtained by equally distributing *Qh,b* into one-half the total number of fixtures on the branch or header for more than two fixtures; for an odd number of total fixtures, decrease by one; for one fixture, apply the full value of *Qh,b*.

Individual vent developed length shall be increased by 20 percent of the distance from the vent stack to the fixture vent connection on the vent branch or header.

Table 5-23 Minimum Diameter and Maximum Length of Individual Branch Fixture Vents and Individual Fixture Header Vents for Smooth Pipes

Diameter of Vent Pipe (Inches)	Individual Vent Airflow Rate (Cubic Feet Per Minute)																			
	Maximum Developed Length of Vent (Feet)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
½	95	25	13	8	5	4	3	2	1	1	1	1	1	1	1	1	1	1	1	1
¾	100	88	47	30	20	15	10	9	7	6	5	4	3	3	3	2	2	2	2	1
1	-	-	100	94	65	48	37	29	24	29	17	14	12	11	9	8	7	7	6	6
1 ¼	-	-	-	-	-	-	-	100	87	73	62	53	46	40	36	32	29	26	23	21
1 ½	-	-	-	-	-	-	-	-	-	-	-	100	96	84	75	65	60	54	49	45
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
For SI: 1 inch = 25.4 mm, 1 cubic foot per minute = 0.4719 L/s, = 304.88 mm.																				

5.5.19 Computerized Vent Design

5.5.19.1 Design of vent system

The sizing, design and layout of the vent system shall be permitted to be determined by approved computer program design methods.

5.5.19.2 System capacity

The vent system shall be based on the air capacity requirements of the drainage system under a peak load condition.

5.6 Traps, Interceptors-And Separators

5.6.1 General

5.6.1.1 Scope

This section shall govern the material and installation of traps, interceptors and separators.

5.6.2 Trap Requirements

5.6.2.1 Fixture traps

Each plumbing fixture shall be separately trapped by a water-seal trap, except as otherwise permitted by this code... The vertic.al distance from the fixture outlet to the trap weir shall not exceed 24 inches (610 mm) and the horizontal distance shall not exceed 30 inches (610 mm) measured from the centerline of the fixture outlet to the centerline of the inlet of the trap. A fixture shall not be double trapped.

5.6.2.2 Size of fixture traps

Fixture trap size shall be sufficient to drain the fixture rapidly and not less than the size indicated in Table 5.24. A trap shall not be larger than the drainage pipe into which the trap discharges.

Table 5-24 Drainage Fixture Units for Fixtures and Groups

Drainage Fixture Units for fixtures and Groups		
Fixture Type	**Drainage Fixture Unit Value as Load Factors**	**Minimum Size of Trap (inches)**
Automatic clothes washers, commercials [a-g]	3	2
Automatic clothes washers, residential [g]	2	2
Bathroom group as defined in Section 1.2 (1.6 gpf water closet)[g]	5	-
Bathroom group as defined in Section 1.2 (water Closet flushing greater than 1.6 gpf)[f]	6	-
Bathtub[b] (with or without overhead shower or Whirlpool attachments)	2	1 ½
Bidet	1	1 ¼
Combination sink and tray	2	1 ½
Dental lavatory	1	1 ¼
Dental unit or cuspidor	1	1 ¼
Dishwashing machine, [c] domestic	2	1 ½
Drinking fountain	½	1 ¼
Emergency floor drain	0	2
Floor drains	2	2
Kitchen sink, domestic	2	1 ½
Kitchen sink, domestic with food waste grinder and/or dishwasher	2	1 ½
Laundry tray (1 or 2 compartments)	2	1 ½
Lavatory	1	1 ¼
Shower	2	1 ½
Service sink	2	1 ½
Sink	2	1 ½
Urinal	4	Note d
Urinal, 1 gallon per flush or less	2[e]	Note d
Urinal, non water supplied	0.5	Note d
Wash sink (circular or multiple) each set of faucets	2	1 ½
Water closet, flush meter tank, public or private	4[e]	Note d
Water closet, Private (1.6 gpf)	3[e]	Note d
Water closet, private (flushing greater than 1.6 gpf)	4[e]	Note d
Water closet, public (1.6 gpf)	4[e]	Note d
Water closet, public (flushing greater than 1.6 gpf)	6[e]	Note d

For SI: 1 inch = 25.4 mm, 1 gallon = 3.785 L (gpf = gallon per flushing cycle).

a. For traps larger than 3 inches, use Table 5.26

b. A showerhead over a bathtub or whirlpool bathtub attachment does not increase the drainage fixture unit value.

c. See Section 5.7.2.2 and 5.7.2.3 for methods of computing unit value of fixtures not listed in the table or for rating of devices with intermittent flows.

d. Trap size shall be consistent with the fixture outlet size

e. For the purposes of computing loads on building drains and sewers, water closets and urinals shall not be rated at a lower drainage fixture unit unless the lower value use are confirmed by testing.

f. For fixtures added to a dwelling unit bathroom group, add the dfu value of that additional fixture to the bathroom group fixture count.

g. See Section 5.2.2.6.3 for sizing requirements for fixture drain, branch drain, and drainage stack for an automatic clothes washer standpipe.

5.6.2.3 Trap setting and protection

Traps shall be set level with respect to the trap seal.

5.6.2.4 Recess for trap connection

A recess provided for connection of the underground trap, such as one serving a bathtub in slab-type construction, shall have sides and a bottom of corrosion- resistant, insect- and vermin proof construction.

5.6.2.5 Acid-resisting traps

Where a vitrified clay or other Brittle ware, acid-resisting trap is installed underground, such trap shall be embedded in concrete extending 6 inches (152mm) beyond the bottom and sides of the trap.

5.6.3 Materials, Joints And Connections

5.6.3.1 General

The materials and methods utilized for the construction and installation of traps, interceptors and separators shall comply with this section and the applicable accepted standard. The fittings shall not have ledges, shoulders or reductions capable of retarding or obstructing flow of the piping.

5.7 Preliminary Data for Design

5.7.1 General

Before the drainage system for a building or group of buildings is designed and constructed, accurate information regarding the site conditions is essential. This information may vary with the individual scheme.

5.7.2 Fixture Units

5.7.2.1 Values for fixtures

Drainage fixture unit values as given in Table 5.24 designate the relative load weight of different kinds of fixtures that shall be employed in estimating the total load carried by a soil or waste pipe, and shall be used in connection with Tables 5.25 and 5.22 of sizes for soil, waste and vent pipes for which the permissible load is given in terms of fixture units.

Table 5-25 Building Drains and Sewers

Diameter of Pipe (Inches)	Maximum Number of Drainage Fixture Units Connected to any Portion of the Building Drain or the Building Sewer, Including Branches of the Building Drain [a]			
	Slope per foot			
	1/16 inch	1/8 inch	**1/4 inch**	**1/2 inch**
1 ¼			1	1
1 ½			3	3
2			21	26
2 ½			24	31
3		36	42	50
4		180	216	250
5		390	480	575
6		700	840	1,000
8	1,400	1,600	1,920	2,300
10	2,500	2,900	3,500	4,200
12	3,900	4,600	5,600	6,700
15	7,00	8,300	10,000	12,00
For SI: 1 inch = 25.4 mm, 1 inch per foot = 83.3 mm/m. a)The minimum size of any building drain serving a water closet shall be 3 inches				

5.7.2.2 Fixtures not listed in Table5.24

Fixtures not listed in Table5.24 shall have a drainage fixture unit load based on the outlet size of the fixture in accordance with Table 5.26. The minimum trap size for unlisted fixtures shall be the size of the drainage outlet but not less than 1.25 inches (32 mm).

5.7.2.3 Values for continuous and semi-continuous flow

Drainage fixture unit values for continuous and semi-continuous flow into a drainage system shall be computed on the basis that 1gpm **(0.06 *Lt/s*)** of flow is equivalent to two fixture units.

Table 5-26 Drainage Fixture Units for Fixture Drains or Traps

Fixture Drain or Trap Size (Inches)	Drainage Fixture Unit Value
1 ¼	2
1 ½	2
2	3
2 ½	4
3	5
4	6
For SI: 1 inch = 25.4 mm.	

5.8 Planning and Design considerations

5.8.1 Aim

The efficient collection and disposal of foul and waste water from a building is of great importance to public health and is an essential part of the construction of the building. In designing a drainage system for an individual building the aim shall be to provide a system of self cleaning conduits for the conveyance of foul and waste and for the removal of such wastes speedily and efficiently to a sewer or other outlet without risk of nuisance and hazard to health.

(1) To achieve this aim a drainage system shall satisfy the following requirements:

a) rapid and efficient removal of liquid wastes' without leakage;
b) prevention of access of foul gases to the building and provision for their escape from the system,
c) adequate and easy access for clearing obstructions;
d) prevention of undue external or internal corrosion, or erosion of joints and protection of materials of construction; and
e) avoidance of air locks, siphonage, proneness to obstruction, deposit and damage.

(2) The realization of an economical drainage system is added by compact grouping of fixtures in both horizontal and vertical directions. This implies that if care is taken and ingenuity brought into play when designing the original building or buildings to be drained, it is possible to group

the sanitary fittings and other equipment requiring drainage; both in vertical and horizontal planes, as to simplify the drainage system and make it most economical.

(3) Efficient and an economical plumbing system can be achieved by planning the toilets in compact grouping with the layout of the bathrooms and observing the following guidelines:

a) Placing of plumbing fixtures around an easily accessible pipe shaft; in high rise buildings the pipe shafts may have to be within the building envelope and easy provision for access panels and doors should be planned in advance, in such cases.
b) Adopting repetitive layout of toilets in the horizontal and vertical directions.
c) Avoiding any conflict with the reinforced cement concrete structure by avoiding embedding pipes in it, avoiding pipe crossings in beams, columns and major structural elements.
d) Identifying open terraces and areas subject to ingress of rainwater directly or indirectly and providing for location of inlets at each level for down takes for disposal at ground levels.

5.8.2 Layout

5.8.2.1 General

The following requirements are suggested to be considered in the design of drainage system:

a) The layout shall be as simple and direct as practicable.
b) The pipes should be laid in straight lines, as far as possible, in both vertical and horizontal planes.
c) Anything that is likely to cause irregularity of flow, as abrupt changes of direction, shall be avoided.
d) The pipes should be non-absorbent, durable, smooth in bore and of adequate strength.
e) The pipes should be adequately supported without restricting movement.
f) Drains should be well ventilated, to prevent the accumulation of foul gases and fluctuation of air pressure within the pipe, which could lead to unsealing of gully or water-closet traps.
g) All the parts of the drainage system should be accessible for feasibility of inspection and practical maintenance.

5.8.2.2 Choice of plumbing system

In selecting one or more of the type of piping systems, the building and the layout of toilets; relationship with other services; acceptability; and any special requirements of users, shall be studied.

(1) Two-pipe systems

(a) This system is ideal when the location of toilets and stacks for the WCs and waste fittings is not uniform or repetitive.
(b) In large buildings and houses with open ground and gardens the sullage water from the waste system can be usefully utilized for gardening and agriculture.
(c) In larger and multi-storied buildings, the sullage is treated within the building for re-use as makeup water for cooling towers for air conditioning system and is also used for flushing water-closets provided it has absolutely no connection with any water supply line, tank or system used for domestic and drinking supply.

(2) One-pipe system

(a) This system is suitable for buildings where the toilet layouts and the shafts are repetitive. It requires less space, and is economical.

(b) Continuous flow of water in the pipe from waste appliances makes it less prone to blockage and makes the system more efficient.

(c) The system eliminates the need for a gully trap which requires constant cleaning.

(d) The system is ideal when the main pipes run at the ceiling of the lowest floor or in a service floor. Two-pipe system may present space and crossing problems which this system eliminates.

(3) Single stack system

(a) The single stack system (without any vent pipe) is ideal when the toilet layouts are repetitive and there is less space for pipes on the wall.

(b) In any system so selected there should be not more than two toilet connections per floor.

(c) The system requires minimum 100 mm diameter stack for a maximum of five floors in a building.

(d) All the safeguards for the use of this system given in 5.8.2.2.1 shall be complied with.

(4) Single stack system (partially ventilated)

The system and the applicable safeguards under this system are the same as for single stack system. The prime modification is to connect the waste appliances, such as wash basin, bath tub or sink to a floor trap.

For detailed information regarding design and installation of soil, waste and ventilating pipes, reference may be made to good practice.

5.8.2.2.1 Safeguards for single stack system

a) as far as practicable, the fixtures on a floor shall be connected to stack in order of increasing discharge rate in the downward direction;

b) the vertical distance between the waste branch (from floor trap or from the individual appliance) and the soil branch connection, when soil pipe is connected to stack above the waste pipe, shall be not less than 200 mm;

c) depth of water seal traps from different fixtures shall be as follows:

Water closets	50 mm
Floor traps	50 mm

Other fixtures directly connected to the stack.

Where attached to branch	40 mm
Waste pipes of	75 mm dia or more
Where attached to branch	75 mm
Waste pipes of less than	75 mm dia

NOTE —When connection is made through *floor* trap, no separate seals are required for individual fixtures.

d) branches and stacks which receive discharges from WC pans should not be less than 100 mm, except where the outlet from the siphonic water closet is 80 mm, in which case a branch pipe of 80 mm may be used. For outlet of floor traps 75 mm diameter pipes may be used;
e) the horizontal branch distance for fixtures from stack, bend(s) at the foot of stack to avoid back pressure as well as vertical distance between the lowest connection and the invert of drain shall be as shown in Figure 5.1; and
f) for tall buildings, ground floor appliances are recommended to be connected directly to manhole/inspection chamber.

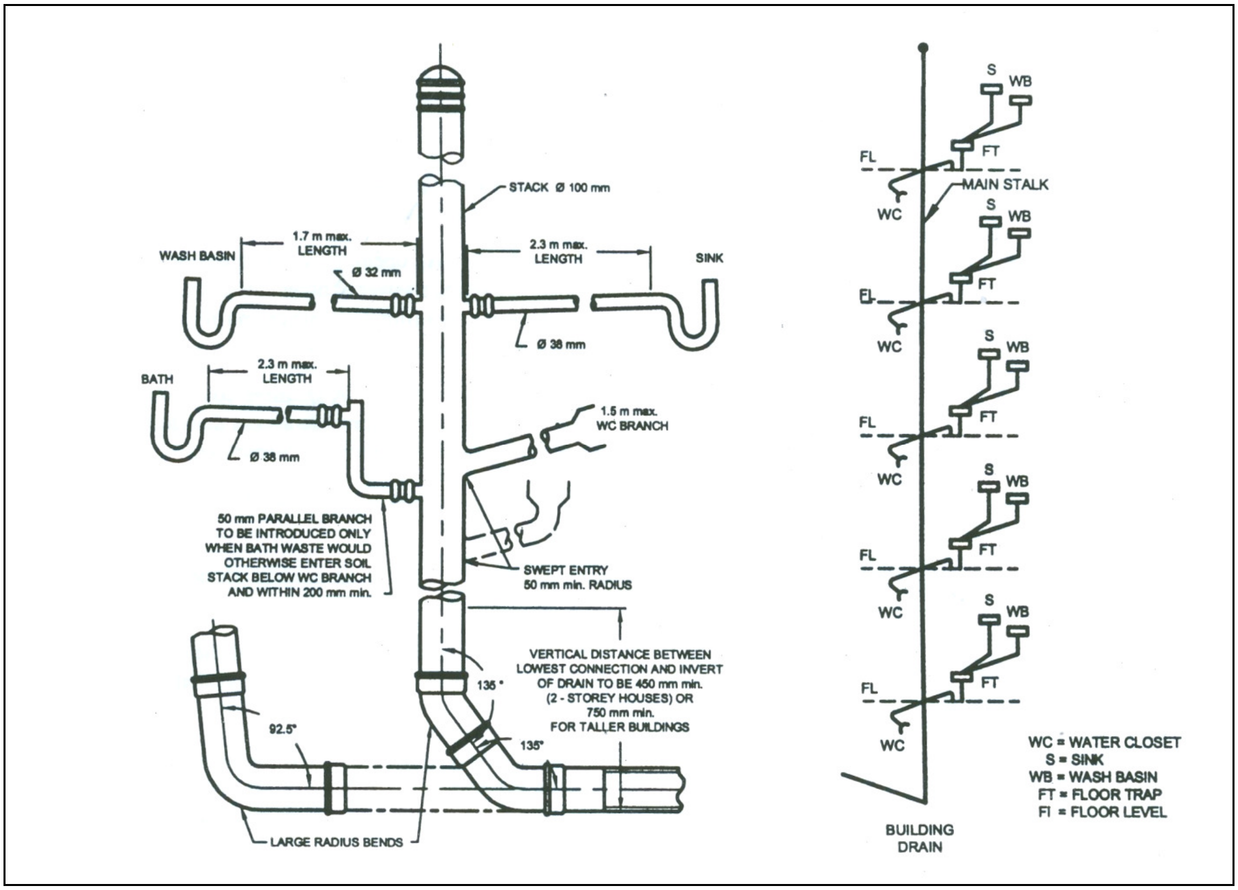


Figure 5-2 Single Stack System-- Main Feature of Design

5.8.3 Drainage (Soil, Waste and Ventilating) Pipes

5.8.3.1 General considerations

(1) Drainage pipes shall be kept clear of all other services. Provisions shall be made during the construction of the building for the entry of the drainage pipes. In most cases this may be done conveniently by building sleeves or conduit pipes into or under the structure in appropriate positions. This will facilitate the installation and maintenance of the services.

(2) Horizontal drainage piping should be so routed as not to pass over any equipment or fixture where leakage from the line could possibly cause damage or contamination, Drainage piping shall never pass over switch-gear or other electrical equipment. If it is impossible to avoid these areas and piping must run in these locations, then a pan or drain tray should be installed below the pipe to collect any leakage or condensation. A drain line should run from this pan to a convenient floor drain or service sink.

(3) All vertical soil, waste, ventilating and antisiphonage pipes shall be covered on top with a copper or heavily galvanized iron wire dome or cast iron terminal guards. All cast iron pipes, which are to be painted periodically, shall be fixed to give a minimum clearance of 50 mm clear from the finished surface of the wall by means of a suitable clamps.

NOTE —Asbestos cement cowls maybe used in case asbestos cement pipes are used as soil pipes.

(4) Drainage pipes shall be carried to a height above the buildings as specified for ventilating pipe (see 5.8.3.4).

5.8.3.2 Soil pipes

A soil pipe, conveying to a drain, any solid or liquid filth, shall be circular and shall have a minimum diameter of 100 mm.

1. Except where it is impracticable, the soil pipe shall be situated outside the building or in suitably designed pipe shafts and shall be continued upwards without diminution of its diameter, and (except where it is unavoidable) without any bend or angle, to such a height and position as to afford by means of its open end a safe outlet for foul air. The position of the open end with its covering shall be such as to comply with the conditions set out in 5.8.3.4 relating to ventilating pipe. Even if the pipes are laid externally, the soil pipes shall not be permitted on a wall abutting a street unless the Authority is satisfied that it is unavoidable. Where shafts for pipes are provided, the cross-sectional area of the shaft shall be suitable to allow free and unhampered access to the pipes and fittings proposed to be installed in the shaft. However in no case cross-section area of the shaft shall be less than a square of one meter side. All pipe shafts shall be provided with an access door at ground level and facilities for ventilation.
2. Soil pipes, whether insider or outside the pipe shall not be connected with any rainwater pipe and there shall not be any trap in such soil pipe or between it and any drain with which it is connected.
3. Soil pipes shall preferably be of cast iron.
4. The soil pipe shall be provided with heel rest bend which shall rest on sound footing, if terminating at firm ground level. When the stack is terminating at the ceiling of a floor, the bend shall be provided with sufficient structural support to cater for the stack dead weight and the thrust developed from the falling soil/ waste. Vertical stack shall be fixed at least 50 mm clear of the finished surface of the wall by means of a suitable clamps of approved type.

5.8.3.3 Waste pipes

Every pipe in a building for carrying off the waste or overflow water from every bath, washbasin or sink to a drain shall be of 32 mm to 50 mm diameter, and shall be trapped immediately beneath such washbasins or sink by an efficient siphon trap with adequate means for inspection and cleaning. Such traps shall be ventilated into the external air whenever such ventilation is necessary to preserve the seal of the trap. Waste pipes, traps, etc, shall be constructed of iron, lead, brass, stoneware, asbestos cement or other approved material. The overflow pipe from washbasin, sinks, etc, shall be connected with the waste pipe immediately above the trap. Vertical pipes carrying off waste water shall have a minimum diameter of 75 mm.

NOTE — Whenever washbasins and sinks have in-built overflow arrangements, there is no need to provide overflow pipes in such cases.

1) Every pipe in a building for carrying off waste water to a drain shall be taken through an external wall of the building by the shortest practicable line, and shall discharge below the grating or surface box of the chamber but above the *inlet* of a properly trapped gully. The waste pipe shall be continued upwards without any diminution in its diameter and (except when unavoidable) without any bend or angle to such a height and position as to afford by means of the open end of the waste pipe, a safe outlet for foul air, the position of the open end and its covering being such as to comply with the conditions.

2) Except where it is impracticable, the common waste pipe shall be situated outside the building and shall be continued upwards without diminution of its diameter (except where it is unavoidable) without any bend or angle being formed to such a height and position as to avoid by means of the open end a safe outlet for foul air, the position of the open end and the covering threat being such as to comply with the conditions set out in 5.8.3.4 relating to ventilating pipe.

3) If the waste pipe is of cast iron, it shall be firmly attached 50 mm clear of the finished surface of the wall by means of a suitable clamps or with properly fixed holder bats or equally suitable and efficient means.

5.8.3.4 Ventilating pipes

Ventilating pipes should be so installed that water can not be retained in them. They should be fixed vertically. Whenever possible, horizontal runs should be avoided. Ventilating pipe shall be carried to such a height and in such a position as to afford by means of the open end of such pipe or vent shaft, a safe outlet for foul air with the least possible nuisance.

1) The upper end of the main ventilating pipe may be continued to the open air above roof level as a separate pipe, or it may join the MSP and/or MWP above the floor level of the highest appliance. Its lower end may be carried down to join the drain, at a point where air relief may always be maintained.

2) Branch ventilating pipes should be connected to the top of the BSP and BWP between 75 mm and 450 mm from the crown of the trap.

3) The ventilating pipe shall always be taken to a point 1500 mm above the level of the eaves or flat roof or terrace parapet whichever is higher or the top of any window within a horizontal distance of 3 m. The least dimension shall be taken as a minimum and local conditions shall be

taken into account. The upper end of every ventilating pipe shall be protected by means of a cowl.

4) In case the adjoining building is taller, the ventilating pipe shall be carried higher than the roof of the adjacent building, wherever it is possible.

5) The building drain intended for carrying waste water and sewage from a building shall be provided with at least one ventilating pipe situated as near as practicable to the building and as far away as possible from the point at which the drain empties into the sewer or other earner.

6. Size of ventilating pipe

(a) The building drain ventilating pipe shall be of not less than 75 mm diameter when, however, it is used as MSP or MWP. The upper portion, which does not carry discharges, shall not be of lesser diameter than the remaining portion;

(b) The diameter of the main ventilating pipe in any case should not be less than 50 mm;

(c) A branch ventilating pipe on a waste pipe in both one-and two-pipe systems shall be of not less than two-thirds the diameter of the branch waste ventilated pipe; subject to a minimum of *25* mm; and

(d) A branch ventilating pipe on a soil pipe in both one-and two-pipe systems shall be not less than *32* mm in diameter.

5.8.3.5 Design of drainage pipes

5.8.3.5.1 Estimation of maximum flow of sewer

a) Simultaneously discharge flow

1) The maximum flow in a building drain or a stack depends on the probable maximum number of simultaneously discharging appliances. For the calculation of this peak flow certain loading factors have been assigned to appliances in terms of fixture units, considering their probability and frequency of use. These fixture unit values are given in Table 5.27.

2) For any fixtures not covered under Table 5.27, Table 5.28 may be referred to for deciding their fixture unit rating depending on their drain or trap size.

3) From Tables 5.27 and 5.28, the total load on any pipe in terms of fixtures units may be calculated knowing the number and type of appliances connected to this pipe.

4) For converting the total load in fixture units to the peak flow in liters per minute, Figure 5.3 is to be used.

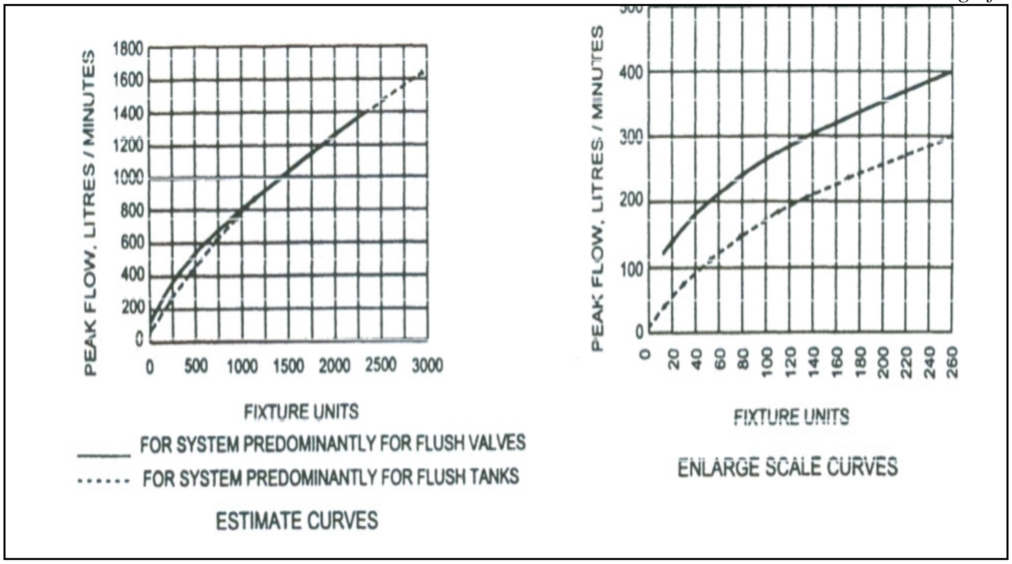


Figure 5-3 Peak Flow Load Curves

5) The maximum number of fixture units that are permissible various recommended pipe size in the drainage system are given in Tables 5.29 and 5.30.
6) Results should be checked to see that the soil, waste and building sewer pipes are not reduced in diameter in the direction of flow. Where appliances are to be added in fixture, these should be taken into account in assessing the pipe sizes by using the fixture units given in Tables 5.27 and 5.28.

b)Maximum discharge flow

The maximum rate of discharge flow shall be taken as three times the average rate, allowance being made in addition for any exceptional peak discharges. A good average rule is to allow for a flow of liquid wastes from buildings at the rate of 3 litres per minute per 10 persons.

Table 5-27 Fixture Units for Different Sanitary appliance or Groups

SI. No (1)	Type of Fixture (2)	Fixture Unit Value as Lad Factors (3)
i	One bathroom group consisting of water-closet, washbasin and bath tub or shower stall:	
	a) Tank water-closet	6
	b) Flush –value water –closet	8
ii	Bath tub (1)	3
iii	Bidet	3
iv	Combination sink –and-tray (drain board)	3
v	Drinking fountain	½
vi	Floor traps (2)	1
vii	Kitchen sink, domestic	2
viii	Wash basin, ordinary (3)	1
ix	Wash basin, surgeon's	2
x	Shower stall, domestic	2
xi	Showers (group) per head	3
xii	Urinal, wall lip `	4
xiii	Urinal, stall	4
xiv	Water-closet, tank-operated	4
xv	Water-closet, valve-operated	8

1. A shower head over a bath tub does not increase the fixture unit value
2. Size of floor trap shall be determined by the area of surface water to be drained.
3. Washbasins with 32 mm and 40 mm trap have the same load value.

Table 5-28 Fixture Units for Fixtures Based on Fixture Drain on Trap Size

SI. No. (1)	Fixture Drain on Trap Size (2)	Fixture Unit Value (3)
i	32 mm and smaller	1
ii	40 mm	2
iii	50 mm	3
iv	65 mm	4
v	85 mm	5
vi	100 mm	6

Table 5-29 Maximum Number of Fixture Units that can be Connected to branches and Stacks

SI. No. (1)	Diameter of Pipe mm (2)	Maximum Number of Fixture Units[1] that can be Connected			
		Any Horizontal Fixture Branch[2] (3)	One Stack of 3 Storey in Height or 3 Intervals (4)	More Than 3 Storeys in Height	
				Total for Stack (5)	Total at one storey or Branch Interval (6)
i	30	1	2	2	1
ii	40	3	4	8	2
iii	50	6	10	24	6
iv	65	12	20	42	9
v	75	20	30	60	16
vi	100	160	240	500	90
vii	125	360	540	1,100	200
viii	150	620	960	1,900	350
ix	200	1,400	2,200	3,600	600
x	250	2,500	3,800	5,600	1000
xi	300	3,900	6,000	8,400	1500
xii	375	7,000	-	-	-

1. Depending upon the probability of simultaneous use of appliances considering the frequency of use and park discharge rate.
2. Does not include branches of the building sewer.

Table 5-30 Maximum Number of Fixture Units that can be connected to Building Drains and Sewers

SI. No. (1)	Diameter of Pipe (2)	Maximum Number of Fixture Units that can be Connected to Any Portion [1] of the Building Drain or the Building Sewer for Graduate			
		1/200 (3)	1/100 (4)	1/50 (5)	1/25 (6)
i	100	-	180	216	250
ii	150	-	700	840	1000
iii	200	1,400	1,600	1,920	2,300
iv	250	2,500	2,900	3,300	4,200
v	300	3,900	4,600	5,600	6,700
vi	375	7,000	8,300	10,000	12,000
1.Includes branches of the building sewer					

Table 5-31 Different Diameter Pipes Giving Velocity and Corresponding Discharge at Minimum and Maximum Gradient

SI. No. (1)	Diameter mm (2)	Minimum Gradient (Velocity: 0.75 m/s) (3)	Discharge at the Minimum Gradient (m^3/min) (4)	Maximum Gradient (Velocity: 2.4m/s) (5)	Discharge at the Maximum Gradient (m^3/min) (6)
i	100	1 in 57	0.18	1 in 5.6	0.59
ii	150	1 in 100	0.42	1 in 9.7	1.32
iii	200	1 in 145	0.73	1 in 14	2.40
iv	230	1 in 175	0.93	1 in 17	2.98
v	250	1 in 195	1.10	1 in19	3.60
vi	300	1 in 250	1.70	1 in 24.5	5.30

5.8.3.5.2 Gradients

1) The discharge of water through a domestic drain is intermittent and limited in quantity and, therefore, small accumulations of solid matter are liable to form in the drains between the building and the public sewer. There is usually a gradual shifting of these deposits as discharges take place. Gradients should be sufficient to prevent these temporary accumulations building up and blocking the drains.

2) When flow occurs in drain piping, it should not entirely fill the cross-section of the pipe under flow condition. If the pipe were to flow full, pressure fluctuations would occur which could possibly destroy the seal of the traps within the building. The approximate gradients which give this velocity for the sizes of pipes likely to be used in building drainage and the corresponding discharges when following half-full are given in Table5.31.

3) In cases where it is practically not possible to conform to the ruling gradients, a flatter gradient may be used, but the minimum velocity in such cases shall on no account be less than 0.61 m/s and adequate flushing should be done.

4) On the other hand, it is undesirable to employ gradients giving a velocity of flow greater than 2.4 m/s. Where it is unavoidable, cast iron pipes shall be used. The approximate gradients, which give a velocity of 2.4 m/s for pipes of various sizes and the corresponding discharge when flowing half-full are given in Table 5.27.

5) The discharge values corresponding to nominal diameter and gradient given in Table5. 27 are based on Manning’s formula (n = 0.015).

NOTE — Subject to the minimum size of 100mm, the sizes of pipes shall be decided in relation to the estimated quantity of flow and the available gradient.

5.8.3.6 Drain appurtenances

5.8.3.6.1 Trap

All traps shall be protected against siphonage and back pressure ensuring access to atmospheric air for air circulation and preserving the trap seal in all conditions.

1) A trap may be formed as an integral trap with the appliance during manufacture or may be a separate fitting called an attached trap which may be connected to the waste outlet of the appliance.

2) Traps should always be of a self-cleansing pattern. A trap, which is not an integral part of an appliance, should be directly attached to its outlet and the pipe should be uniform throughout and have a smooth surface,

3) The trap should have minimum size of outlet/exit, same as that of largest waste inlet pipe.

4) Traps for use in domestic waste installations and all other traps should be conveniently accessible and provided with cleansing eyes or other means of cleaning.

5) The minimum internal diameter for sanitary appliances shall be as follows:

Table 5-32 Minimum Internal Diameter of Waste Outlet

Sanitary Appliance	Minimum Internal Diameter of Waste Outlet mm
Soil appliance	
a. Indian and European type water-closets	100
b. Bed pan washers and slop sinks	75
c. Urinal with integral traps	50
d. Stall urinals (with not more than 120 mm of channel drainage)	40
e. Lipped urinal small/large	
Waste appliances	
f. Drinking fountain	25
g. Wash basin	32
h. Bidets	32
i. Domestic sinks and baths	40
j. Shower bath trays	40
k. Domestic bath tubs	50
l. Hotel and canteen sinks	50
m. Floor traps (outlet diameter)	65

5.8.3.6.2 Floor drains

All toilets/bathrooms in a building desirably should be provided with floor drains to facilitate cleaning.

1) Floor drains shall connect into a trap so constructed that it can be readily cleaned and of a size to serve efficiently the purpose for which it is intended. The trap shall be either accessible from the floor drain or by a separate cleanout within the drain.

2) Floor drain should be provided in mechanical equipment rooms, where pumps, boilers, water chillers, heat exchangers and other air conditioning equipments are periodically drained for maintenance and repair. Boiler requires drain at safety relief valve discharge.

3) Strategically floor drains are required to be located in buildings with wet fire protection sprinkler systems to drain water in case of activation of sprinkler heads.

5.8.3.6.3 Cleanouts

The cleanout provides access to horizontal and vertical lines and stacks to facilitate inspection and means to remove obstructions common to all piping systems, such as solid objects, greasy wastes, hair and the like.

(1) Cleanouts in general should be gas and water-tight, provide quick and easy plug removal, allow ample space for rodding tools, have means of adjustments to finished floor level, be attractive and be designed to support whatever load is directed over them.

(2) Waste lines are normally laid beneath the floor slab at a sufficient distance to provide adequate back-fill over the joints. Cleanouts are then brought up to floor level grade by pipe extension pieces.

(3) The size of the cleanout within a building should be the same size as the piping up to 100 mm. For larger size piping 100 mm cleanouts are adequate for their intended purpose.

(4) Cleanouts are suggested to be provided at the following locations:
   (a) Inside the building at a point of exit, Y junction branch or a trap.
   (b) At every change of direction greater than 45°.
   (c) At the base of all stacks.
   (d) At the horizontal header, receiving vertical stacks and serving the purpose of offset header.

5.8.4 Drainage System Sizing

5.8.4.1 Maximum Fixture Unit Load

The maximum number of drainage fixture units connected to a given size of building sewer, building drain or horizontal branch of the building drain a given size of building drain or horizontal branch of the building drain shall be determined using Table 5.25. The maximum number of drainage fixture units connected to a given size of horizontal branch or vertical soil or waste stack shall be determined using Table 5.22.

5.8.4.1.1 Horizontal Stack Offsets.

Horizontal stack offsets shall be sized as required for building drains in accordance with Table 5.25.

5.8.4.1.2 Vertical Stack Offsets.

Vertical stack offsets shall be sized as required for straight stacks in accordance with Table 5.22.

5.8.4.2 Future Fixtures.

Where provision is made for the future installation of fixtures, those provided for shall be considered in determining the required sizes of drain pipes.

5.8.5 Offsets In Drainage Piping In Buildings of Five Stories or More

5.8.5.1 Horizontal Branch Connections Above or Below Vertical Stack Offsets.

If a horizontal branch connects to the stack within 2 feet (610 mm) above or below a vertical stack offset and the offset is located more than four branch intervals below the top of the stack, the offset shall be vented in accordance with Section 5.5.15.

5.8.5.2 Horizontal Branch Connections to Horizontal Stack Offsets.

Where a horizontal stack offset is located more than four branch intervals below the top of the stack, a horizontal branch shall not connect within the horizontal stack offset or within 2 feet (610 mm) above or below such offset.

5.8.5.3 Horizontal stack offsets.

A stack with a horizontal offset located more than four branch intervals below the top of the stack shall be sized as follows:

1) The portion of the stack above the offset shall be sized as for a vertical stack based on the total number of drainage fixture units above the offset.

2) The portion of the stack below the offset shall be sized as for the offset or based on the total number of drainage fixture units on the entire stack, whichever is larger [See Table 5.22, Column 5].

5.8.5.4 Offsets below lowest branch

Where a vertical offset occurs in a soil or waste stack below the lowest horizontal branch, change in diameter of the stack because of the offset shall not be required. If a horizontal offset occurs in a soil or waste stack below the lowest horizontal branch, the required diameter of the offset and the stack below it shall be determined as for a building drain in accordance with Table 5.25.

5.8.6 Computerized Drainage Design

5.8.6.1 Design of drainage system.

The sizing, design and layout of the drainage system shall be permitted to be designed by approved computer design methods.

5.8.6.2 Load on drainage system.

The load shall be computed from the simultaneous or sequential discharge conditions from fixtures, appurtenances and appliances or the peak usage design condition.

5.8.6.2.1 Fixture discharge profiles

The discharge profiles for flow rates versus time from fixtures and appliances shall be in accordance with the manufacturer's specifications.

5.8.6.3 Selections of drainage pipe sizes

Pipe shall be sized to prevent full-bore flow.

5.8.6.3.1 Selecting pipe wall roughness.

Pipe size calculations shall be conducted with the pipe wall roughness factor (ks), in accordance with the manufacturer's specifications and as modified for aging roughness factors with deposits and corrosion.

5.8.6.3.2 Slope of horizontal drainage piping.

Horizontal drainage piping shall be designed and installed at slopes in accordance with Table 5.15.

SECTION 6

6 EXTERNAL DRAINAGE SYSTEM FOR BUILDINGS

6.1 Scope

(1) This Section sets out requirements and recommendations.

a) For the design, layout, construction, testing and maintenance of foul and groundwater drainage system construction in the ground under and around buildings;

b) For the design and construction of septic tanks, cesspools and subsoil disposal systems; and

c) Regarding pipe materials and their jointing.

6.2 General

(1) Layout

The layout of the drainage system should be as simple as possible. Changes of direction and gradient should be minimized and as easy as practicable. Access points should be provided only if blockages could not be cleared without them. Connections of drains to other drains or to sewers should be made obliquely, and in the direction of flow.

Pipes should be laid to even gradients and any change of gradient should be combined with an access point

Any bends should be limited to positions in or close to inspection chambers or manholes

Bends should have as large a radius as practicable.

(2) A drainage system should be designed, installed and maintained so as to convey and discharge its contents without causing a nuisance or danger to health arising from leakage, blockage or surcharge.

(3) Every building in which plumbing fixture are installed and premises having thereon, shall have a connection to a public sewer. Where no public sewer line exists, the drains shall be connected to a sewage disposal system approved by the Building Official.

(4) Ground water (subsoil water) should be drained from around and underneath buildings, structures, etc. Whenever required. This should be effected through plain open-jointed porous or perforated pipes laid in trenches or graded granular or other porous material fills or packs around and underneath the area to be drained.

(5) Access should be provided at all bends junctions. Access, in this context, is meant to be an inspection chamber or manhole. Inspection chambers and manholes should be sited so as to avoid the need for acute changes in direction of flow from branch drains.

(6) For drains laid outside buildings, the following shall be satisfied.

(a) Part of pipework laid under buildings should be limited to short branches and should be made to enter manholes (or inspection chamber) at no more than 2.0m from the building line whenever possible.

(b) The drain trench should not impair the stability of a building. When drains are laid parallel to the foundation, care should be taken not to undermine the foundations.

(7) For drains laid under buildings the following shall be met:

(a)The effects of possible differential settlement between the building and the drains shall be limited to acceptable standards

(b) Differential settlement in drains shall be accommodated by means of flexible joints or other considerations by a qualified engineer.

(8) A free passage of air should be maintained through the system.

(9) (a) Existing drains which are or will be disused when superseded by new installations should be traced, grubbed up and removed.

(b) Where the requirement in (a) above is impracticable, discussed drains should be filled with suitable material such as weak concrete, cement grout or similar material to prevent their collapse or, in appropriate circumstances, sealed against ingress of water and vermin.

6.3 Foul Drainage

6.3.1 General

(1) Clause 6.3 applies to drains of the separate system.

(2) All subsoil drainage system and surface runoff due to rain shall be excluded from the system; i.e., foul drainage system up to a treatment unit, collection point or disposal system.

(3) In determining the size and gradient of the building sewer (external drain), the following shall be observed.

(4) The fixture-unit values contributing to the flow in a given drain shall be added and the equivalent peak flow rate (*l/s*) obtained. When the drain carries continuous flows from other sources, their rates can be added to the above peak flow rate.

6.3.2 Determination of Pipe Size and Gradient

(1) A pipe diameter and gradient shall be selected taking account of the provisions and requirements in (2) to (4) below (see Figures 6.2 and 6.3).

(2) Risk of recurring blockages during normal use shall be minimized by ensuring a high standard of drain and manhole construction throughout the system and that pipes are not unacceptably oversized.

(3) (a) Foul drains, starting from manholes adjacent to or within buildings, should be of minimum size DN100, except for WC discharges which should be DN150.

(c) The size of a drain pipe and its gradient should be so chosen that at peak flow, the risk of induced trap siphonage is minimized by ensuring adequate air movement in the drain, but not exceeding a proportional depth of 0.75.

(4) (a) Choice of gradients should be such as to maintain self-cleansing velocity (min.06m/s), but will not make scouring (max.3.0m/s)

(b) Where it is expected that a drain may be affected by settlement, selected gradient should be such as to ensure a satisfactory fall will be maintained.

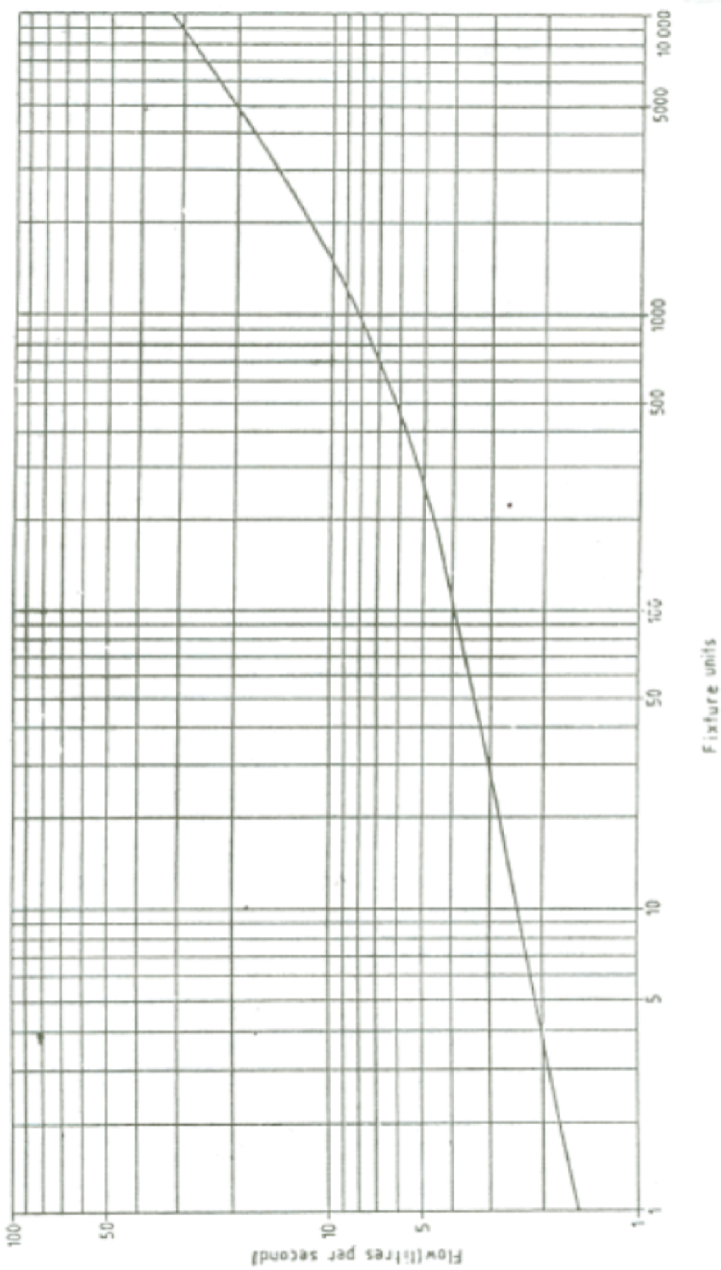


Figure 6-1 Design for foul drainage pipes-Conversion of fixture units to flow rates

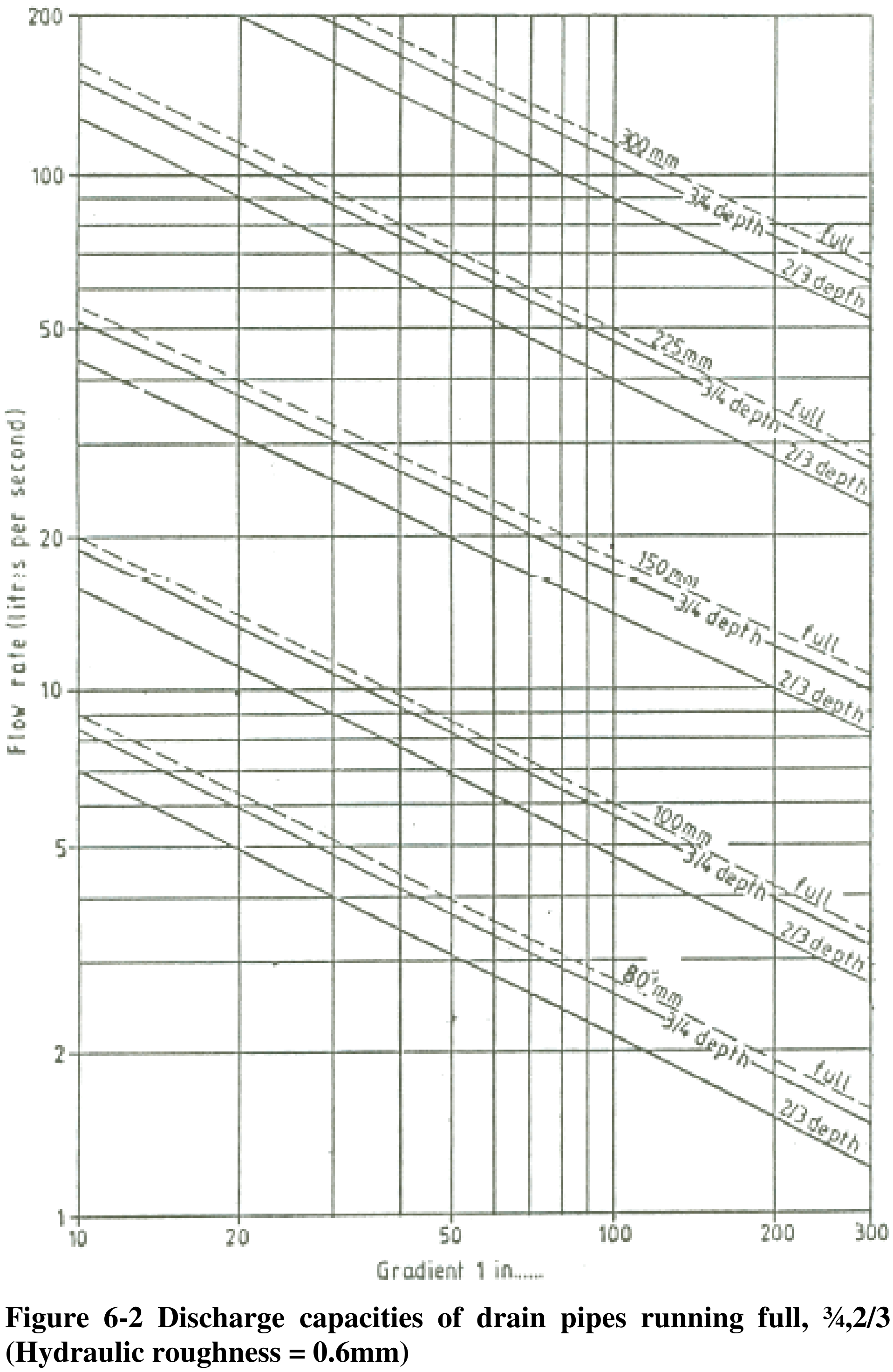


Figure 6-2 Discharge capacities of drain pipes running full, ¾,2/3 proportional depth (Hydraulic roughness = 0.6mm)

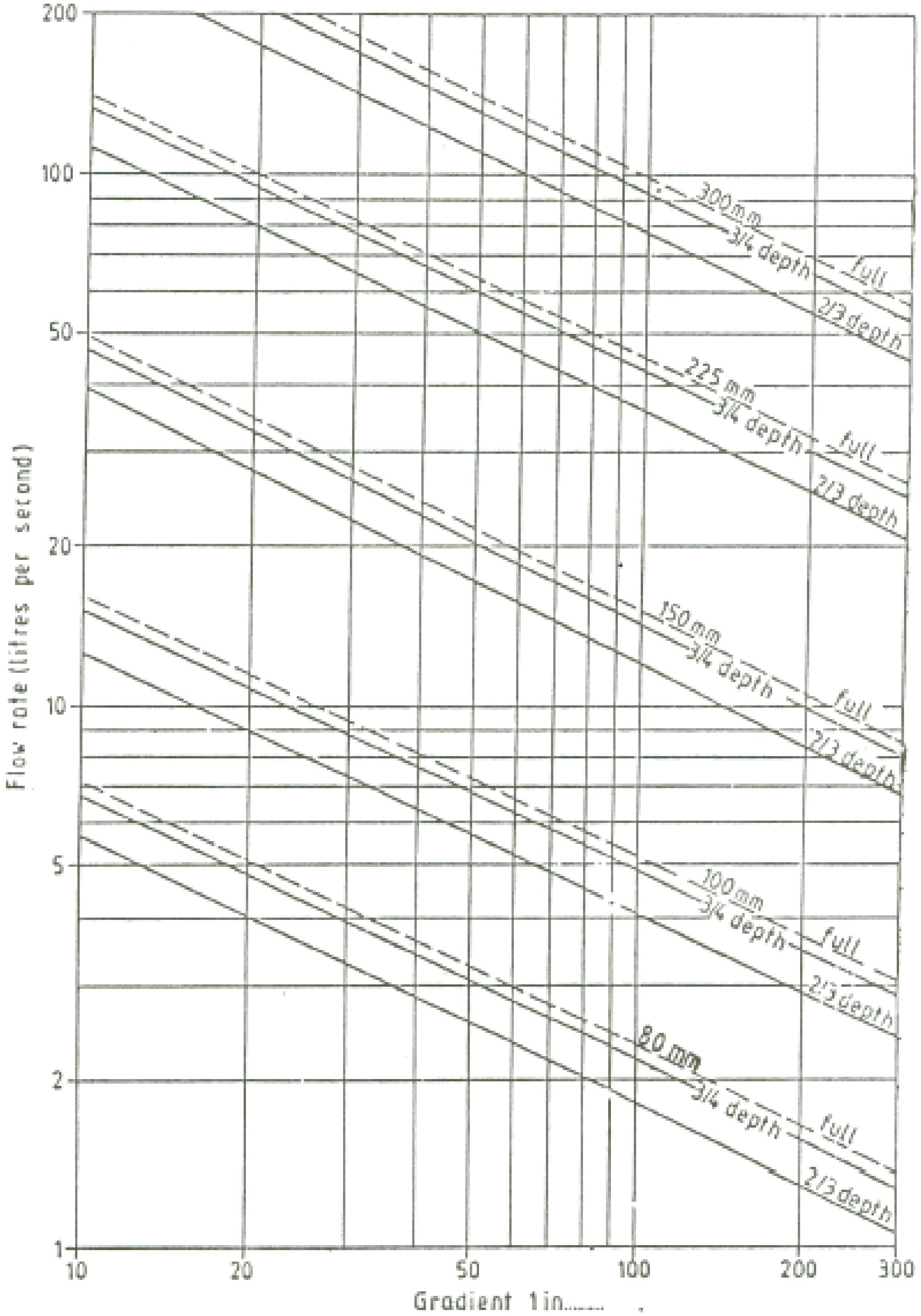


Figure 6-3 Discharge capacities of drain pipes running full, ¾, 2/3 proportional depth (Hydraulic roughness = 1.5mm)

6.3.3 Determination of Pipe Size and Gradient

(1) A connection to a foul drain within the premises of a building should be effected via an inspection chamber or manhole.

(2) (a) A branch connection should have an angle of entry not greater than 900 at the internal face of an inspection chamber or manhole.

(b) Where practicable, it should be installed at half pipe level of the main channel to provide cascade entry, and the connection so shaped as to discharge into it with minimum turbulence and without causing backing-up into other connections.

(3) (a) Where the invert level of an incoming drain is 1.0m or more above that of the manhole, a drop-pipe shall be provided to convey the discharge to the lower level**.**

(b) Suitable access should be provided to facilitate testing and clearing of blockages.

(c) Where space is available without adversely affecting access of working space, a drop-pipe may be installed inside a manhole.

(d) When the drop-pipe is larger than 150.omm, it should be constructed outside the manhole and provided with structural protection and support suited to the pipe material and ground conditions (see Figure 6.7).

(4) (a) the drain connection to a public sewer system should be agreed with the appropriate drainage authority.

(b) The connector drain (to sewer system) should be laid so as to provide an adequate hydraulic gradient and to ensure that the minimum length of drain is subjected to backflow would the sewer surcharge.

(d) When a drain is connected to a septic or settlement tank, the entry velocity should be restricted so as to ensure that quiescent conditions within the tank are disturbed as little as possible.

(e) Provision should be made for effectively rodding the incoming drain and its connection to any tank or unit.

(5) Lifting installations

Where gravity drainage is impracticable or protection against flooding due to surcharge in downstream sewers is required, a lifting (pumping) installation will be needed.
Package lifting installations are available which are suitable for installation within buildings. Floor mounted units may be particularly suited for installation in basements.

Where foul drainage from a building is to be pumped, the effluent-receiving chamber should be sized to contain 24-hour inflow to allow for disruption in service. The capacity of the receiving chamber should be based on the calculated daily demand of the water intake for the building. Where only a proportion of the foul sewage is to be pumped, then the capacity should be based pro-rata. In all pumped systems the controls should be so arranged to optimize pump efficiency and be fitted with a suitable alarm system to alert the owner of any malfunction.

6.4 Groundwater Drainage

6.4.1 General

(1) (a) All pipes for field drains should be laid to planned lines and gradients

(b) Plain pipes should be laid with open-joints; but perforated and porous pipes should be fitted tightly together. Perforated pipes should be laid with holes equally distributed about the vertical axis of the drain.

(c) Trenches for plain-ended or ogee0jointed pipes should be just wide enough at the bottom to accommodate the pipes and should be trimmed to form a uniform bed for the pipes.

(2) Where a rubble drain is required, it should be constructed by excavating a trench and filling it with selected rubble or stone through which water can percolate. Renewal may be necessary from time to time.

(3) (a) where a trench drain is required, it should be constructed by excavating a trench and laying therein open-jointed pipes, perforated or porous material.

(b) The pipes should be surrounded with fill through which water can percolate freely.

(4) (a) Where it is essential to prevent the migration of some soil particles with groundwater, filter drain shall be used.

(b) The pipe should be surrounded with graded granular material or a polypropylene or fabric filter designed in accordance with acceptable engineering practice.

(5) The selection of an appropriate layout of ground-water drain shall depend on the nature of the subsoil and the topography of the site.

6.4.2 Groundwater Drains under Buildings

(1) The laying of groundwater drains under buildings, unless and otherwise required by the engineer, should be avoided.

(2) Should it be necessary to route a groundwater drainage system under a building, this should be done using jointed non-porous pipes.

6.4.3 Disposal of Groundwater Discharge

(1) A groundwater drainage system shall discharge through sand trap or directly into a ditch or a watercourse.

(2) In suitable ground conditions, groundwater drainage system shall discharge to a soakaway, preferably, through a sand trap.

(3) Where the alternatives in (a) or (b) above for groundwater disposal are not available; a groundwater drainage system may discharge into a surface water through a sand trap.

(4) Under special circumstances, a groundwater drainage system may discharge into a foul drain (after treatment) through an intercepting trap.

6.4.4 Disposal of Groundwater Discharge

(1) The flow rate of ground water shall be estimated from an in-depth assessment of the quantity of run-off likely to affect the area concerned, natural slope of the terrain around the area, terrain soil permeability and maximum water table.

6.4.5 Drain Pipe Sizes

(1) Drain pipe sizing shall be in accordance with the provisions of Clause 6.3.2.
(2) Main groundwater drains should be not less than DN150, and the branches not less than DN100.

6.5 Laying of Drain Pipes

6.5.1 General

Where a drain is to be located in a road, public place or like in an open trench, it shall be installed as follows:

(a) It shall be laid to an even grade, straight, and have no lipped joints or internal projections.

(b) It shall have a minimum number of changes of grade and direction.

(c) It shall be continuously supported under the barrel, other than for cast iron and ductile iron pipes and fittings.

(d) It shall be protected against damage by a minimum cover as specified in Table 6.1.

(e) It shall be watertight

(f) It shall have the interior of each pipe cleared of any foreign matter before it is laid and prior to commissioning.

(g) It shall have a drop manhole installed to connect drains at different elevations.

(h) Where the presence of any obstacle prevents the drain from being laid at an even grade and with the required cover, then, whenever practicable, the drain shall pass beneath the obstacle at an even grade with a drop permitted only at the point of connection or in any other way approved by the Building Official.

6.5.2 Proximity to Other Services

(1) Electrical cables and gas pipes:

(a) When installed aboveground, shall not be within 100.0mm of any drain pipe.

(b) When installed belowground, shall not be within 600.0mm of either side of a below ground drain. Whenever this separation cannot be achieved, the distance may be reduced to 300mm provided that the electric cable or gas pipe is suitably marked with bricks, stone masonry or equivalent durable material painted red, within the exclusion zone (see Figure 6.4).

(2) Any belowground cross-over of a drain within the exclusion zone shall:

(a) Cross at an angle of not less than 45^0;

(b) Have a vertical separation of not less than 100.0mm; and

(c) Be suitably marked with bricks, stone masonry or equivalent durable material, painted red.

(3) Stormwater pipes shall be located at least 100.0mm clear of any part of the foul drain. The pipes shall be watertight and properly supported.

(4) The proximity of foul drain pipes to water service pipes shall be as in 4.14.3(3).

(5) Where services, other than electric cables or gas pipes, cross any part of the drain, the service shall be not less than 25.0mm above the drain and access fir maintenance shall not be impeded.

6.5.3 Depth of Cover

(1) Drains shall be laid in a manner that provides protection against mechanical damage and deformation due to vehicular loadings.

(2) Drains shall be laid with a depth of cover, measured from the top of the pipe socket to the finished ground surface, as specified in Table 6.1.

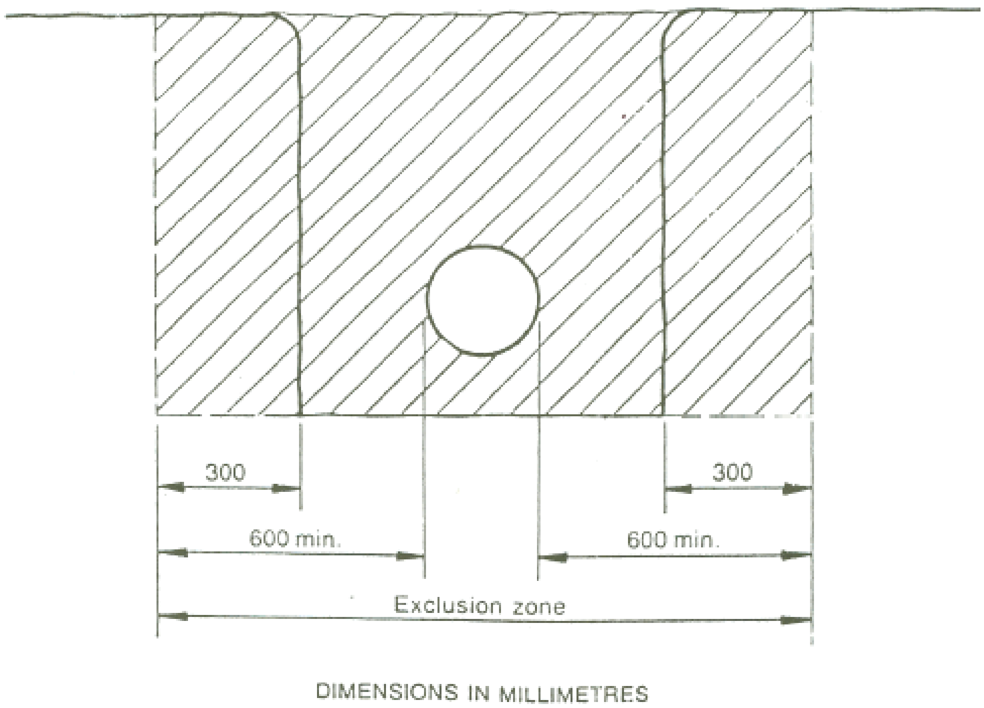


Figure 6-4 Exclusion zone for electric cables and gas pipes

Table 6-1 Minimum depth of cover

Location	**Minimum depth of cover [mm]**	
	Cast iron ductile iron	Other approved materials
(a)Public roads, right-of-way, and other place subject to heavy vehicular traffic	300	700
(b) Other driveways	300	600
(c)Elsewhere	Nil	300*

* Except as provided in (3) and (4) below.

(3) Drains constructed of materials other than cast iron or ductile iron, having less than the minimum cover as specified in Table 6.1. shall be covered by at least 50.0mm of overlay and then shall be paved with:

(a) 100.0mm minimum thickness of reinforced concrete, where subject to heavy vehicular loading,

(b) 75.0mm minimum thickness of brick or concrete paving, where subject to light vehicular traffic, or

(c) 50.0mm minimum thickness of brick or concrete paving, where not subject to vehicular traffic.

(4) Drains below ground and under buildings may be laid with less than the minimum cover specified in Table 6.1 provided that:

(a) 25.0mm overly separates the drain from a reinforced concrete slab; or

(b) The drain is adequately protected from mechanical damage.

(5) Drains in proximity to footings and foundations shall comply with the following:

(a) Drains passing under a strip footing at not less than 45^0 (between the drain and the longer side of the footing) shall have a minimum clearance of 25.0mm from the top of the pipe to the underside of any footing.

(b) Drains laid through footings or walls, other than below-ground external walls, shall be left with an annular space of not less than 25.0mm filled with a liner of flexible material.

(c) Pipes may be laid through below-ground external walls provided that:

(d) Where the excavation is to be laid parallel to a footing, the excavation shall comply with Clause 6.61 and the trench shall be located beyond a 450 angle from the base of the footing (see Figure 6.5).

(e) Requirements for pile systems shall be determined by a qualified engineer.

6.6 Excavation, Bedding, Support and Backfilling

6.6.1 Excavation of Trenches

(1) Any trench excavation in which the sides are not self-supporting or when required by the Building Official shall comply with the relevant regulations which require that these trenches be adequately supported against collapse.

(2) Trenches shall be made with a minimum clearance of 100.0mm on each side of the drain barrel measured to the inside of the sheeting or side of trench. The trench width up to the level of the top of the drain shall be kept as narrow as practicable, but not less than the above minimum clearance.

(3) Where a trench has been excavated deeper than necessary, the excess depth shall be filled either with bedding material compacted to achieve a density as near to the original soil density as possible or with concrete.

(4) Excavation by a machine shall not be carried out within 600.0mm of the point of connection to the municipal sewer main or any other sewage receiving unit such as tanks, channels, etc.

(5) Excavation in water-charged ground shall be in accordance with the following:

(a) Consideration shall be given to the effect on adjacent buildings and the trench.

(b) The water level shall be lowered below the base of the proposed trench and maintained at that level during excavation, laying of the drain, and backfilling of the trench.

(c) Dewatering shall be carried out in accordance with the following:

(i) Gravity drainage, pumping or similar methods may be used.

(ii) The removed water shall be discharged into a location where it will not cause a nuisance or damage.

(iii) The removed water shall not discharge, either directly or indirectly, into sewer.

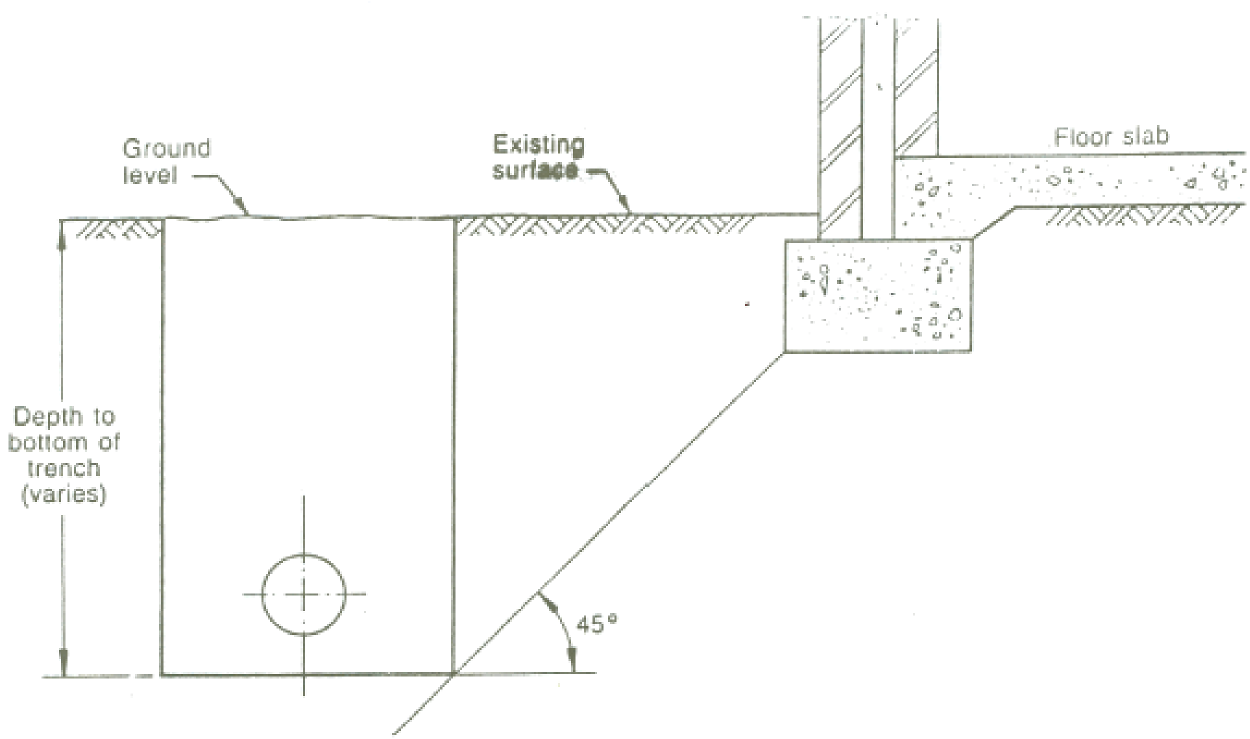


Figure 6-5 Typical footing detail

6.6.2 Bedding of Drains

6.6.2.1 General

(1) The bed on to which drains are laid shall be adequate to continuously support the installed drain accommodating the loads from the pipeline and surrounding ground, in accordance with the following:
  (a) In stable sand, drains shall be directly supported on the undisturbed base of the trench provided that the base of the trench is free any rocks or tree roots.
  (b) In loam, clay, rock, shale, gravel, or ground containing hard objects, drains shall be supported on a bedding material placed in the base of the trench.
  (c) Ground water or surface water entering the trench shall not disturb the bedding materials.

6.6.2.2 Materials

(1) Materials used for bedding of rains shall comply with the following:
  (a) Quarry crushed hard stone shall have a maximum aggregate size of 10.0mm.
  (b) Uniform crushed hard stone shall be of size ranging from 2.5mm to 10.0mm.
  (c) Sand shall be free from clay, gravel, shells, or hard particles
  (d) Cement mortar shall be composed of 1:4, Portland cement to clean sand, and clean water.
  (e) Excavated material shall be free from clay, gravel, shells, or other hard particles.

6.6.2.3 Installation

(1) Bedding shall be installed in accordance with the following:
  (a) Crushed hard stone shall:
    (i) Extend across the full width of the base of the trench;
    (ii) Be a minimum depth of 75.0mm measured below the bottom of the pipe; and
    (iii) Directly support the pipes and fittings.

  (b) Cement mortar bedding shall:
    (i) Be a minimum depth of 50.0mm measure below the barrel of the pipe;
    (ii) Be not less than 75.0mm wide
    (iii) Be kept clear of flexible joints;
    (iv) Have pipes supported at not greater than 1.5m centres prior to placing the mortar bedding; and
    (v) Be used where the base of the trench is rock or shale and where the grade is greater than 20%.

  (c) Excavated material shall:

(i) Be thoroughly compacted by tamping in layers not greater than 75.0mm;
(ii) Extend for the full width of the trench; and
(iii) Have a minimum thickness of 75.0mm.

6.7 Inspection Chambers and Manholes

6.7.1 General

(1) Every drain length should accessible for maintenance, rodding and cleaning through the provision of inspection chambers and manholes or otherwise.

(2) Inspection chambers and manholes should be provided at the head of each run of drain, at changes in direction, gradient or pipe diameter and every 30.0m straight run of drains.

(3) Inspection chambers and manholes should be resistant to water penetration, be durable and designed to minimize the risk of blockage.

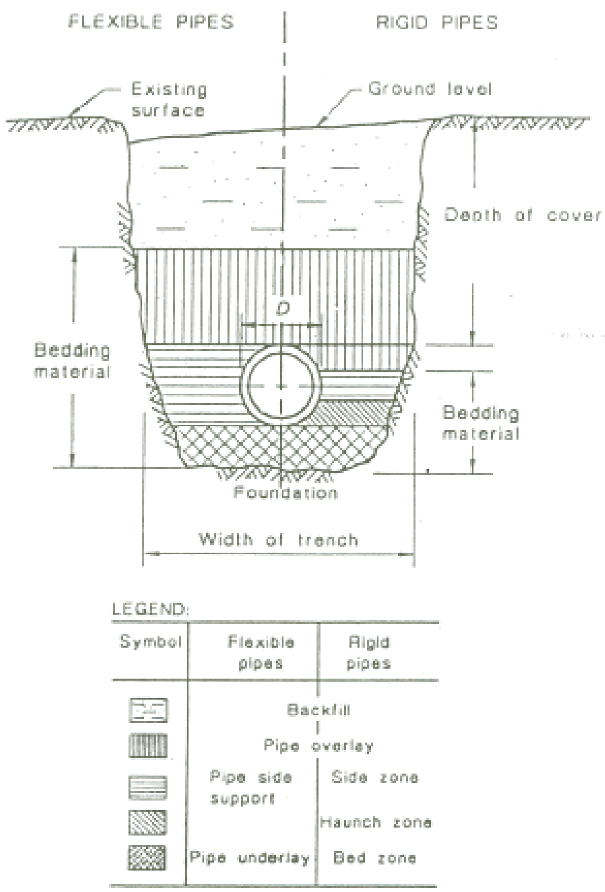


Figure 6-6 Bedding of drains

6.7.2 Dimensions

(1) The size of inspection chambers should be such that the drain can be cleaned from the surface.

(2) The design of manhole should permit entry without restricting operational space.

(3) Subject to the minima given in Table 6.2, internal dimensions for manholes with a number of branches may be estimated for straight inverts as follows:

a) *Length*: The length should be the sum of 100.0mm on each side of the branch pipe, the diameter of the pipe on the side having most branches for each pipe, plus an allowance at the downstream end for the angle of entry.

b) *Width*: The width should be the sum of the widths of the benching plus 150.0mm or the diameter of the main drain, whichever is greater. The benching width should be 300.0mm where there are branches or 150.0mm where there is no branch. Where manhole or inspection chambers with curved channels cannot be avoided, their dimensions should be based on the foregoing principles.

6.7.3 Materials of construction for Inspection Chambers and Manholes

(1) Materials of construction for inspection chambers and manholes may include:

a) Brickwork, concrete block, stone masonry;
b) Concrete, in situ and precast; and
c) Plastics (UPVC, ployropylene and GRP

(2) For blockwork (blockwork chambers):

a) The wall thickness should be adequate to resist external pressures due to soil and ground water, but in any case not less than 150.0mm;
b) Durability and resistance to water penetration should be achieved by using bricks and concrete blocks complying with the relevant standards. In addition, all mortar joints should be completely filled and flush pointed as the work proceeds;
c) The roofing concrete slab for brick inspection chambers and manhole should be designed to carry the weight of any ground above plus all probable superimposed loads.
d) An inspection chamber or manhole should be built on base of concrete of minimum quality C-15 not less than 150.0mm thick;

e) Pipes of size DN300 or larger, when built into walls, should have either one brick relieving arch turned over the pipe to the full thickness of the brick work or a concrete lintel or other effective means of relieving the load,

f) The pipes in and out of manholes should be bedded on mortar and built in as the brickwork proceeds.

(3) For inspection chambers and manholes constructed of in-situ concrete, the walls should be of adequate thickness to resist external pressures. Roofing and base of inspection chambers and manholes are as in (2) above.

(4) (a) Inspection chambers and manholes of precast concrete shall be built in sections.

(b) Materials, dimensions and test methods should comply with the relevant standards.

(c) The base may be either of precast concrete or in situ concrete similar to that described as in (2) above.

(d) Where manholes or inspection chambers are constructed wholly above the water table, joints sealed with cement mortar can be satisfactory. In waterlogged ground or where the water table is above the base, joints should be made watertight, preferably using a non-rigid jointing materials such as a mastic sealant or a rubber ring joint.

(5) Plastics manholes, if employed either as integral bases or as complete chamber units, should comply with the relevant Ethiopian Standards or equivalent.

6.7.4 Channels and Bending

(1) An open channel of half-round section should extend the whole length of the inspection chamber or manhole.

(2) A vertical benching should be formed from the top edge of the main channel to a height not less than that of the soffit of the outlet. It should be round off to a radius of about 25.0mm and then sloped upwards to meet the wall of the chamber.

(3) (a) side branches of diameters upto and including 150.0mm should discharge to the main channel in the direction of flow.

(b) Vertical and side benching should be shaped so as to contain the flow without permitting fouling and to facilitate rodding of branch drains.

(c) A branch with a diameter of more than 150.0mm should be set with the soffit level with that of the main drain.

(4) (a) In inspection chambers and manholes of brickwork, precast concrete or in situ concrete, main and branch channels should be bedded and jointed in 1:3 cement mortar.

(b) To ensure that the channel and the branch junctions are properly supported, the bedding and the benching should be laid in a single operation.

(5) Plastics channel sections are available and could be used in a similar manner to traditional materials, but special care should be exercised to ensure adequate bonding with the base.

6.7.5 Access to Manholes-Step Irons

1. For brick or in-situ concrete manholes, they should be built into the wall at intervals of between 230.0mm and 300.0mm.

2. (a) The step irons should preferable be set and staggered in two vertical runs which should be constant at approximately 300.0mm centres horizontally.

   (b) The top step iron should be positioned so that direct access to it by an operator is practicable and should be fixed not more than 750.0mm below the surface, depending on the cover and slab arrangement.

   (c) The lowest step iron should be fixed not more than 300.0mm above the benching. Precast concrete manholes should have step irons let in.

Table 6-2 Minimum dimensions for inspection chambers and manholes

Types of access	Depth to invert (m)	Minimum internal dimension	
		Rectangular length and width	Circular diameter [mm]
Inspection chamber or manhole	≤0.6	400x400	400
	≤1.0	600x600	600
	≤1.75	1000x750	1000
	≤2.5	1200x750	1200
	>2.5	1400x900	1500
Manhole shaft*	>2.5	900x800	900

*Minimum height of chamber in shafted manhole shall be 2.0m from crown of pipe to underside of reducing slab.

6.7.6 Drop-Pipe Manholes (See Figure 6.7)

(1) If the drop-pipe is outside the manhole, a continuation of the drain should be built through the manhole wall to form a rodding eye.

(2) A drop-pipe fitted within the manhole should be able to withstand maintenance operations and have rodding access.

6.7.7 Inspection Chamber and Manhole Covers and Slabs

(1) Covers and frames from ductile and grey cast iron, cast steel and precast concrete for manholes and inspection chambers shall be in accordance with the relevant Ethiopian Standards or equivalent.

(2) Covers used for manholes within buildings should be airtight and mechanically secured.

6.8 Interceptors, Sewage Treatment and Disposal Units

6.8.1 Interceptors

(1) (a) Interceptors shall be provided, where necessary, for the proper handling of wastes containing grease, oil, flammable wastes, sand and other ingredients harmful to the building drainage system and the public sewer.

(b) Only wasters having a mixture of light and heavy solids or-liquids and solids having various specific gravities may be treated and then separated in an interceptor.

(c) The size, type and location of each interceptor shall be approved by the Building Official.

(2) (a) A grease and oil interceptor (separator) ,when it is deemed necessary, shall be installed in the drainage line leading from sinks, drains or other appliances in the following establishments:

(i) Restaurants,

(ii) Hotel kitchens,

(iii) Cafeterias,

(iv) Clubs or others from which grease and oil can be introduced into the drainage system.

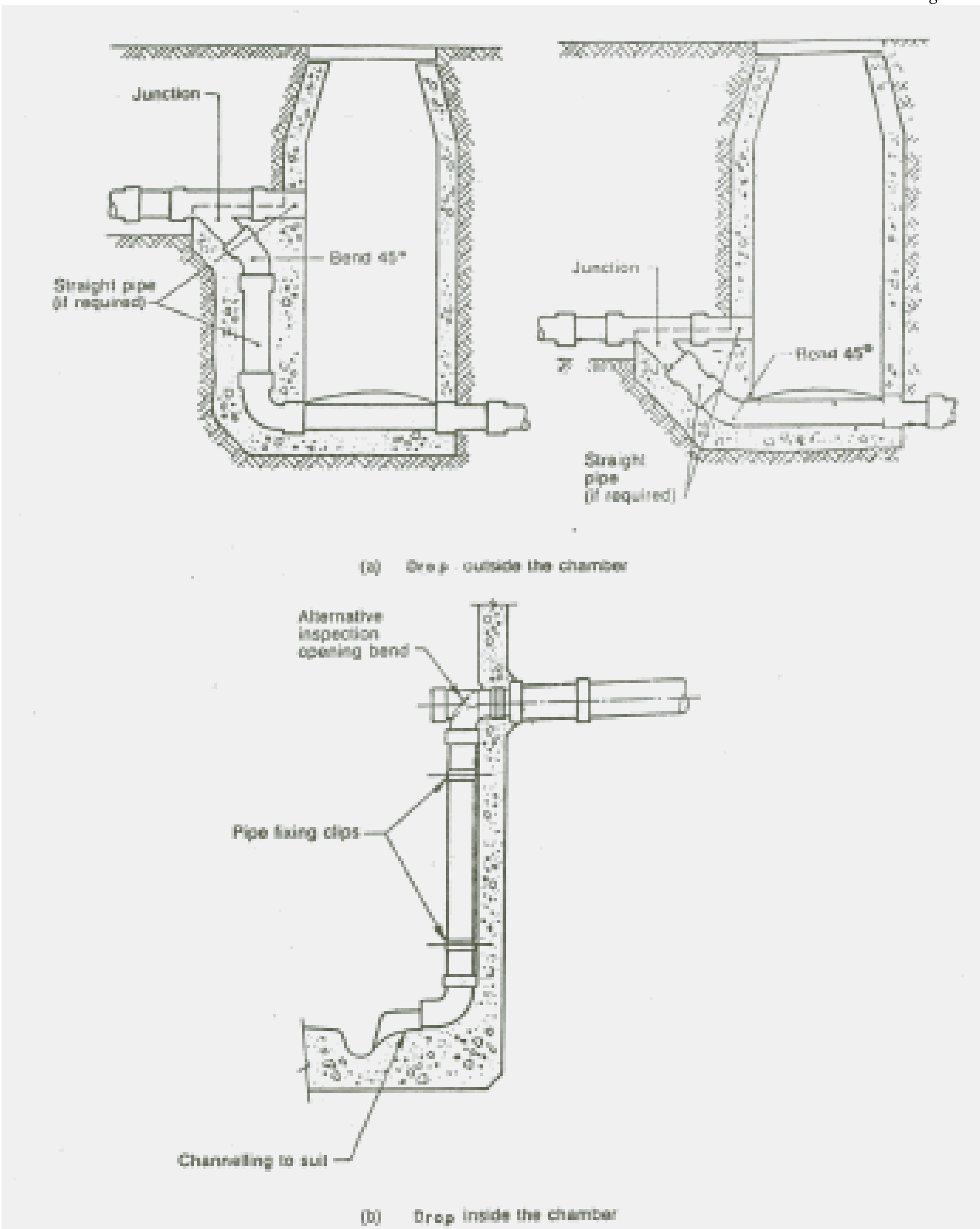


Figure 6-7 Drop pipe at manholes

(b) A grease and oil intercept may not be required for kitchens of private dwelling units.

(c) An oil interceptor shall be installed in the drainage line or section of the line where oil or other flammable wastes can be introduced or admitted in the drainage line by accident or otherwise. These include motor-vehicles storage and servicing stations.

(3) Sand and heavy-solids interceptors shall be so designed and located as to be readily accessible for cleaning and shall have a water seal of not less than 150.0mm.

(4) Discharge from commercial laundries, bottling plants and slaughterhouses, which include rags, buttons, broken glass, feathers and other solids, should be intercepted before being discharged into the drainage system.

(5) (a) Interceptors shall be so designed that they will not become air bound if closed covers are used (otherwise their contents might be siphoned).

(b) Each interceptor shall be vented.

(6) Each interceptor shall be so installed as to provide ready accessibility to the cover and means for servicing and maintaining the interceptor in working and operating condition.

(7) (a) Interceptors shall be maintained in efficient operating condition by periodic removal of accumulated grease, oil, sand, grit, solids, etc.

(b) A maintenance schedule shall be worked out to this effect alongside the design proper.

6.8.2 Septic Tanks

(1) A septic tank installation shall be provided for both settlement of solids and partial biological treatment of sewage.

(2) The design criteria shall assume that surface water and subsoil water be excluded from entering septic tanks.

(3) Septic tanks should be watertight so that they permit neither ingress of groundwater nor egress of sewage to the ground.

(4) Septic tanks could be constructed from bricks, stone masonry, in-situ concrete and large precast concrete pipes.

(5) Septic tanks could also be prefabricated from steel and plastic materials.

(6) Brick and stone masonry-work should normally be in cement mortar.

(7) Where construction in water-logged ground is unavoidable, provision should be made for the prevention of tank flotation during construction, emptying and maintenance.

(8) Calculation of the total capacity of septic tanks shall be made on the basis of the number of persons to be served, water consumption and sludge production per capita and the hydraulic detention time.

(9) The design of septic tanks shall be such that the discharge of solids in the tank effluent is kept to a minimum.

(10) The following formula is recommended for general use where dislodging is carried out at a reasonable number of times per year, two years, etc.

$$V= \tau_{sed}.p.q/10^3+u_1.\tau_{ac}.p/10^3 \quad (6.1)$$

Where:-

V	is effective volume of tank, in m3
τ_{sed}	is hydraulic detention time, in day (s) (minimum, 1.0 day).
p	is user population
q	is water consumption per capita per day, in litres (see Table 4.4, Section 4).
V1	is sludge production per capita per day, in litres (0.15*l*)
τ_{ac}	is number of days between de-sludgings (minimum, 365.0 days).

(11) For rectangular tanks, at least two or three should be used in series either by constructing two or three separate tanks or by dividing a single tank into two or three by partitions (see Figure 6.8).

(12) (a) In all cases of (11) above, the compartments should be not less than 1200.0mm deep below the top water level.

(b) The first compartment should have a capacity of not less than two-third of the total tank capacity with a length of not less than twice its width and the subsequent compartments should have a combined capacity of not less than one third of the total capacity.

(c) In order to facilitate desludging operations, the floor of the first compartment should have a fall of 1:4 towards the inlet end.

(13) Duplicate tanks, preferably with half calculated capacities could be provided in parallel.

(14) The design of septic tank inlets and outlets shall be such that they facilitate introduction of crude sewage and removed of the clarified liquid with the least possible disturbance of the settled sludge or the surface scum.

a) An inlet for rectangular tanks of not more than 1200.0mm wide should be a T-shaped dip pipe not less than the nominal bore of the incoming drain, fixed inside the tank, with the top limb rising above the scum level and the bottom jimb extending about 450.0mm below the top water level.

b) For tanks in excess of 1200.0mm in width, two submerged inlets having inverts at the same level should be introduced (see Figure 6.8).

c) A baffle should be provided 150.0mm from the inlet end of the tank, extending 150.0mm below the invert of the inlet pipe and 150.0mm above the top water level.

d) Where the incoming drain has a steep gradient, at least the last 12.0m should be laid at a gradient not steeper than 1:50 in order to minimize turbulence.

(15) (a) The final outlet for tanks which are less than 1200.0mm wide should be by a 100.0mm nominal bore dip pipe fixed inside the tank in a similar manner to the inlet dip pipe in 14(a) above and 25.0mm below it.

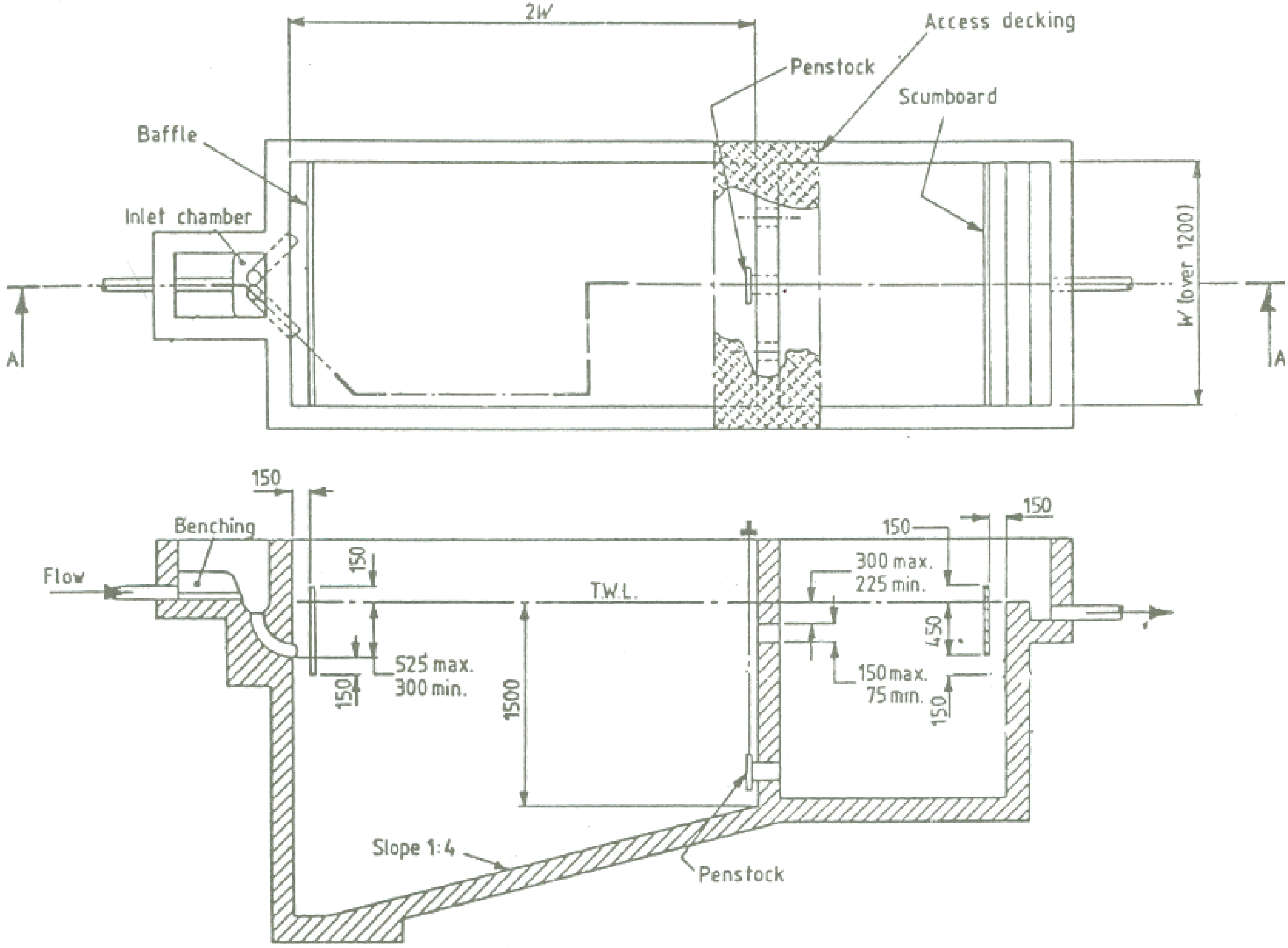
(b)For wider tanks, it is necessary to use a weir outlet extending the full width of the tank and protected by a scumbcard such as suitable protected timber, plastics or asbestos cement fixed 150.0mm from the weir and extending 150.0mm above and 450.0mm below the top water level.

(16) (a) A roof should be provided to a septic tank, in which case it may be wholly or partially removable and be of concrete or timber.

(b)If fixed, the roof should have adequate access openings, with covers including those necessary for inspection and cleansing of the inlet and outlet arrangements.

(17) Where it is not roofed, a septic tank should be provided with a protective fence to prevent unauthorized access.

(18) (a) Septic tanks should be located as far away as practicable from buildings, water wells and water reservoirs (underground) to prevent contamination of domestic water supply and reduce the risk of nuisance in case of malfunctioning; i.e. overflow through manholes, gas emission through vent pipes, etc.



All dimensions are in millimeters. Section A-A

Note Tanks are normally fitted with covers.

Figure 6-8 Typical septic tank-two compartments

6.8.3 Cesspools

(1) where an appropriate sewer is not available and sewage treatment is impracticable, cesspools, could be provided.

(2) Cesspools should be and remain impervious to ingress of ground or surface water and to leakage.

(3) Cesspools should be provided only where emptying facilities are available or are possible to introduce.

(4) Cesspools should be limited to serve only single houses.

(5) A capacity of not less than 45 days storage should be allowed.

(6) Effective storage time shall depend on the population served, the water consumption and whether there is any infiltration into the foul drains.

(7) (a) A cesspool shall be cylindrical, square or rectangular in plan to suit the condition of the site.

(b) The depth from the cover of the access opening to the floor of the tank should not normally exceed 4.0m on a flat site and may need to be further restricted on a sloping site to limit the suction lift when emptying.

(8) The inlet drain should be provided with access appropriate for the drainage system and should terminate with the pipe projection about 75.0mm clear of the inside of the wall of the cesspool.

(9) Cesspools shall be properly ventilated.

(10) (a) The access to cesspools should not be less than 600.0mm clear opening to enable inspection, maintenance or removal of consolidated sludge.

(b) The chamber should be made as sage a place of work as possible and sage methods of working should be adopted.

(11) (a) The site selected for a cesspool should not be so near to any inhabited building as to be liable to become a source of nuisance or a danger to health (a minimum of 15.0m is desirable) and it is essential that not well, stream, river, spring or aquifer likely to be used for drinking or domestic purposes is liable to be polluted.
(b) The site of the cesspool should preferably be on ground sloping away from and sited lower than any existing building in the immediate vicinity.
(c) the prevailing wind direction should be from the buildings served towards the cesspool.

(d) Adequate means of vehicular access should be provided to the cesspool where emptying by tankers is envisaged.

(12) (a) When a cesspool is to be abandoned, it shall be left in a condition that is neither dangerous nor prejudicial to health.

(b) The requirement in (a) above shall be effected by the removal of the remaining contents and backfilling of the chamber with hardcore or similar stable, non-compressible material, demolition of the structure within 500.0mm of ground level, and re-instatement of the ground surface.

6.8.4 Effluent Disposal

6.8.4.1 Soakaway pit

(1) A soakaway pit shall be used for discharging effluent into pervious subsoils such as gravel, sand, chalk, etc at a level above that of the water table.
(2) The pit shall be covered by a slab incorporating an inspection manhole and cover.

6.8.4.2 Percolation ditch

(1) In less porous subsoils, a subsurface irrigation system percolation ditches) shall be used as more suitable alternative.

(2) (a) Percolation ditches should be very carefully designed and should consist of a system of field drains which should be constructed using porous or perforated pipes, laid in trenches, with a uniform gradient which should be not steeper than 1:200.

(b)The pipes should be laid on a 150.0mm layer of clean gravel or broken stone 20.0mm to 50.0mm grade and the trenches filled to a level 50.0mm above the pipe and covered with strips of plastics material or equivalent laid to prevent the entry of silt.

(c) The remainder of the trench should be filled with normal soil and pipes laid at a minimum depth of 500.0mm below the surface.

(3) If the level of water table rises to within 1.0m of the proposed invert of the irrigation system, it is not normally advisable to use subsurface irrigation.

6.8.4.3 Area of subsurface drainage

(1) The floor area of a subsurface drainage trench or infiltration area of a soakaway pit, A_t in m^2, required to disperse effluents from septic tanks shall be calculated from:

$$A_t = PV_p\ 0.25 \qquad (6.2)$$

Where

P is the number of persons served by the tank

V_P is the percolation value obtained as described in Annex F.

(2) For effluents which have received secondary treatment followed by settlement, the area calculation in (1) above should be reduced by 20%; i.e:

$$A_t = PV_p\ 0.2 \qquad (5)$$

(3) The area determined should be used to calculate either a length of subsurface drainage or, alternatively, the infiltration area of one or more shallow soakaways.

(4) (a) Drainage trenches should be from 300.0mm to 900.0mm wide.

(b) Areas of undisturbed ground 2.0m wide should be maintained between parallel tranches.

6.8.4.4 Underdrains

(1) Where underdrains are necessary, drainage trenches should be constructed not less than 600.0mm deeper than the above trenches and the lower part filled with fine gravel (see Figure 6.49).

(2) A second system of drainage pipes should be laid on the bottom of the trenches to covey surplus drainage to an outfall in a surface ditch or water course.

6.8.4.5 On site Treatment

1. Percolation areas and mounds

A percolation area typically consists of a system of sub-surface irrigation pipes which allow the effluent to percolate gradually into the surrounding soil. Biological treatment takes place naturally in the aerated layers of soil.
Percolation mounds are essentially percolation areas placed above the natural surface of the ground providing an aerated layer of soil to treat the effluent. Percolation areas should be designed by the design engineer

2. **Soil infiltration systems**.
Land drainage pipes should not be used in a percolation trench. Access /inspection pipes should be fitted to the end of the percolation pipes to facilitate the assessment of the proper functioning of the percolation area and to facilitate rodding or scouring of the pipes. There should be a maximum of five trenches attached to each distribution box when designing a gravity system for a percolation area. On sloping sites the pipework should be installed parallel to the contour to aid distribution of the effluent. The infiltration pipes should be inspected before installation to ensure a clean and smooth finish on all cuts and drill holes.

3. Constructed wetlands
Constructed wetland is the generic term used to describe both (gravel- and sand-based) horizontal and vertical flow reed bed systems and soil-based constructed wetlands. The main difference between a constructed wetland and other filter systems is the planting of vegetation in the media where the thick root mass acts as a pathway for the transfer of oxygen from the atmosphere to the root zone (rhizosphere). Pumping may or may not be required for constructed wetland systems depending on the slope of the site and the wetland configuration. They can be used to provide secondary or tertiary treatment to effluent from septic tank or tertiary treatment to packaged wastewater treatment systems. The design and construction of wetlands should comply with the BMP.

4. Intermittent filter systems

This comprises a pump chamber which transfers the partially treated effluent, (generally from a septic tank), onto the filter at regular intervals. The filter may consist of soil, sand, peat or other media. A range of configurations may be considered:

(a) an intermittent soil filter system (soil polishing filter is built in);
(b) an intermittent sand filter followed by a polishing filter (may be inbuilt or offset);
(c) an intermittent peat filter followed by a polishing filter;
(d) an intermittent plastic or media filter followed by a polishing filter;
(e) a constructed wetland or reed bed followed by a polishing filter.

Where a pumped distribution system is used, an alarm should be fitted to alert the user to any malfunction. A polishing filter should be used in conjunction with all intermittent filters.

5. Polishing filters
A polishing filter is a filter system the purpose of which is to provide additional treatment of the effluent and to reduce pollutants such as micro-organisms, phosphorous and in certain cases nitrate nitrogen. It also provides for the hydraulic conveyance of the treated effluent to the ground.

6. Packaged wastewater treatment systems

Packaged wastewater treatment systems may be used to treat wastewater from a building where the site is unsuitable for a septic tank system or they may be used as an alternative to septic tank systems.
The system should be designed for a minimum hydraulic daily load of 150 l/person/day based on the number and size of bedrooms and a minimum organic daily load of 60g BOD/person/day to ensure adequate treatment is provided.
All such systems must have treatment efficiency capable of meeting the minimum applicable performance effluent standards. Monitoring and maintenance of these systems is required to ensure that the effluent is treated to this standard. In nutrient sensitive areas, more stringent performance standards for nitrogen and phosphorous may be necessary.
The sludge storage capacity should be checked with the manufacturer to establish the necessary frequency of de-sludging. All package wastewater treatment systems should be provided with an alarm to indicate operation failure.
Many systems are available including: -
  (a) Biofilm Aerated Filter (BAF) systems;
  (b) Rotating Biological Contactor (RBC) systems;

7. Greywater recovery systems

(1) A greywater recovery system is an installation used to collect, store and treat greywater to a suitable quality and to distribute it for particular specified purposes.

(2) Greywater is water originating from the mains potable water supply that has been used for bathing, washing or laundering clothes.

(3) Water from dishwashers/sinks should be avoided.

(4) Where a greywater recovery system is installed the following guidance should be complied with:

(a) Overground and underground drainage used to collect greywater for recovery and re-use within the building should be designed and constructed in accordance with the general guidance to be set by the design engineer.

(b) All pipework for greywater recovery systems should be easily distinguished and easily recognizable wherever it is physically located (inside a property, in the street, or on private land, etc) to avoid cross-connection and contamination of the potable water supply systems, e.g. for greywater green/black/green bands and the words GREY WATER in black lettering

(c) The maximum stagnation period for greywater water should be 10 days unless otherwise specified by the manufacturer.

(d) After 10 days of stagnation, or the period specified by the manufacturer, all stored reclaimed water (other than in the WC cistern) should be automatically dumped to the foul drain or sewer;

(e) A back-up water supply should be incorporated. Where this is from a potable or mains water supply the back-up supply should be fitted with a backflow prevention device

6.9 Inspection, Testing and Maintenance of Drainage Works

6.9.1 Inspection and Testing of Drainage Works

(1) Drainage works should be inspected and tested in two stages;

a) As the work proceeds, and
b) Immediately before the work is handed over upon completion.

(2) The work should be protected during all stages of construction and the entry of foreign matter into any part of the systems prevented.

(3) Testing sequence shall constitute the following:

a) First stage testing

(i) Tests should be carried out to locate and remedy any defects in soundness that may exist at the time of construction.

(ii) Such test should take place immediately before the work is covered up so as to facilitate replacement of any faulty pipes or pipe fittings or to rectify any joint defect.

(iii) Inspection of the pipeline shall reveal any defects in the support and bedding.

b) Final testing:

(i) Testing and inspection should take place immediately before handover when all relevant work been complete.

(4) Pre-test procedures are as follows:

(a) Before any tests are applied, attention should be given to the safety of the operatives and other persons involved in the testing operation.

(b) It is essential that proper means of access should be provided to the area of work and the sides of any trench or excavation in which work is to be tested adequately supported and free from hazards.

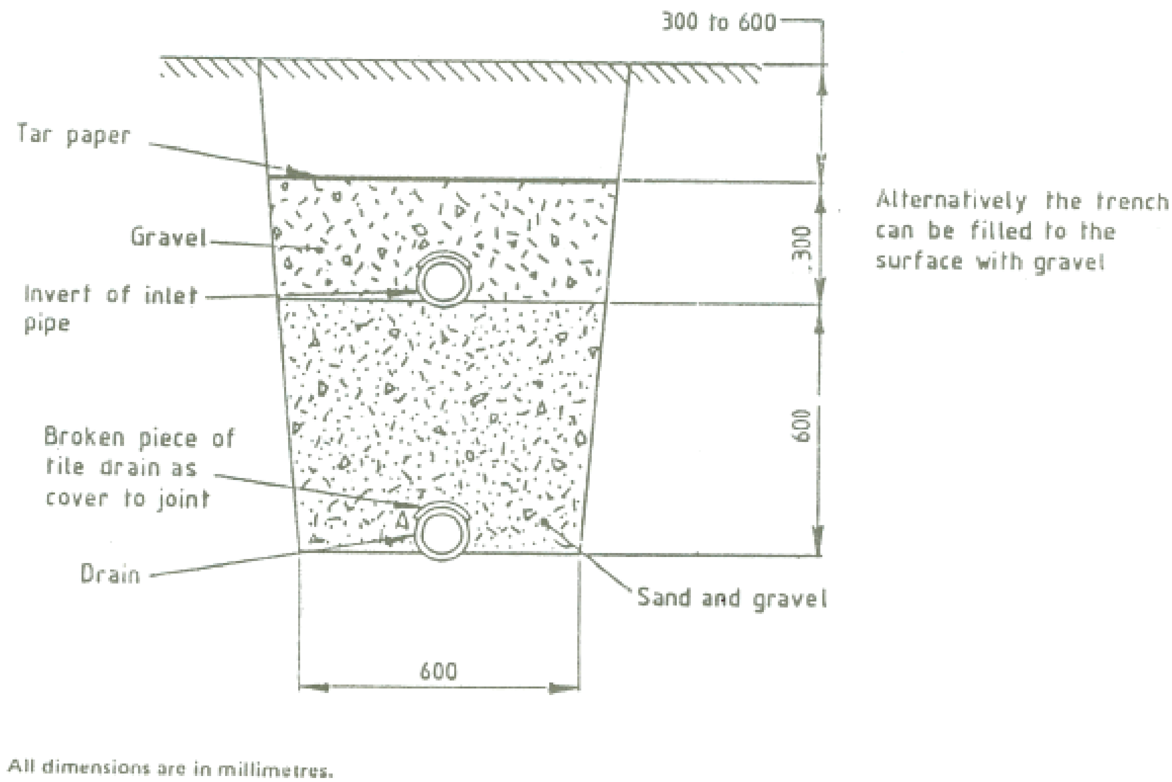


Figure 6-9 Cross-section of typical underdrain

(c) All obstruction, debris and superfluous matter should be removed from sections of pipeline, inspection chambers, manholes, or similar underground chambers and they should be flushed out before testing.

(d) Before any tests are applied, a disc or ball-type profile testing device should be passed through all drains and private sewers between inspection chambers, manholes or other suitable points of access and through all accessible branch drains.

(e) Water tightness: After laying drains and combined drains, including any necessary concrete or other haunching or surrounding and backfilling, all pipes up to 300 mm diameter should be capable of withstanding a final water test to a pressure equal to 1.5 m head of water measured above the invert at the head of the drain, or an air test ensuring that head of water on a manometer does not fall by more than 25 mm in a period of five minutes for a 100 mm water gauge test pressure and 12 mm for a 50 mm water gauge test pressure.
Where the drain is water tested using a stand pipe of the same diameter as the drain, the section of the drain should be filled and left to stand for two hours and topped up.

The leakage over thirty minutes should then be measured and should not be more than 0.05 litres for each metre run of drain for a 100 mm drain - a drop in water level of 6.4 mm/m, and not more than 0.08 litres for a 150 mm drain - a drop in water level of 4.5 mm/m.

To prevent damage to the drain, the head of water at the lower end of the section should not be more than 4 m and it may be necessary to test a drain in several sections.

(5) Soundness tests for gravity drains constitute the following:

(a) ***water test***: Drains shall be tested as follows:

(i) A water test shall be applied to every drain and to any section of an existing drain that has been repaired

(ii) The head or water shall be at least 1.5m at the high end of the drainline and not more than 4.0m at the lower end.

(iii) The test shall be applied by Sealing all openings except the top of the section of the drain to be tested, filling the drain with water to the highest level in that section; and maintaining the water at this level for a period of 2.0hrs, topping up as necessary.

(iv) The test is considered to be successful if the quantity of make-up water (rate of water loss) measured after 2.0hrs does not exceed 1.0l/h per meter diameter linear meter run of pipe. For various pipe diameters, this rate of loss over a 30.omin period may be expressed as follows:

DN100 pipe- 0.05 litres per meter run
DN150 " - 0.08 " "
DN225 " - 0.12 " "
DN300 " - 0.15 " "

(b) ***Interpretation of results***: A change in water level in the test apparatus could be due to one or more of the following causes, which shall be rectified or appropriate allowances made for in the testing procedure:

(i) Absorption by pipes or joints.

(ii) Exposure of pipes in direct sunlight, or changes of ambient temperature when pipes are laid.

(iii) Trapped air,

(iv) Leakage past expanding plugs or bag stoppers.

(c) ***Air test:*** an air test may be applied to the completed work, either in its entirety or in sections, in accordance with the following procedure:

(i) The air pressure test shall consist of applying a pressure of 3.0m water head to the drain and holding this pressure for 3.0min to allow the air temperature to stabilized.

(ii) The air supply shall then be shut off and the time taken for the pressure in the pipe to drop from 2.5m to 2.0m head of water shall be measured.

(iii) The drain is considered to have passed the test if the time taken is greater than 90.os for pipes of size DN225 or smaller, or 180.0s for pipes of sizes DN300 and DN375.

(6) Soundness tests for ancillary work:

(a) The design and construction of ancillary work such as inspection chambers, manholes, oil and grease separators, sumps, septic tanks, cesspools and similar underground structures should ensure a high level of resistance to water penetration, both inwards and outwards.

(b) Where construction work has been effectively carried out, visual inspection may be sufficient for acceptance without testing.

(c) Inspection should always be made to reveal any possible weaknesses in the structure and particular attention should be paid to the following:

(d) Water test

(i) All outlets, inlets and other connection points of the chambers or structures should be fitted with plugs and filled with clean water up to the underside of the covers.

(ii) The water is allowed to stand for up to 8.0hrs for absorption topping up the level as necessary.

(iii) The criterion for acceptance (at this stage) should be that no appreciable flow of water penetrate the structures.

(iv) Where water can be observed issuing from the outside face of the structures at an identifiable point or points, such leakage should be stopped.

(v) The external faces of a structure should not normally be backfilled or concrete surrounded before the test.

6.9.2 Maintenance and Periodic Inspection

(1) Drainage systems should be inspected at regular intervals and, where necessary, thoroughly cleaned out at the same time. Any defects discovered should be made good.

(2) The following operations should be carried out during the periodic cleaning of a drainage system:

(a) Covers of inspection chambers and manholes should be removed and the sides, benching and channels cleaned.

(b) Main and branch drains should be cleaned and, afterwards, should be flushed with clean water. Any obstructions found should be removed and not flushed into system.

(c) Accumulated deposits in interceptors should be removed periodically.

(d) Covers of inspection chambers, manholes and interceptors should be replaced, bedded in suitable grease or other sealing material and/or bolted down as appropriate to the type. Missing bolts and broken items should be renewed.

(3) The drainage system should be cleaned, as appropriate, using one or more of the following methods:

(a) Rodding:

(i) Appropriate cleaning tools and techniques should be chosen to avoid damage to the pipework to be cleaned

(ii) It is important that correctly designed proprietary ends used on the rods.

(iii) Makeshift devices attached to the ends of rods should be avoided as they are not as effective as the correctly designed article and could become detached and create a blockage which would be difficult to remove. Furthermore, it is possible that such devices could cause damage to the pipeline.

(b) High pressure jetting techniques could be suitable for use with all currently available pipe materials and should also be considered.

(c) Shock waves could be induced and transmitted by water to the point of blockage, where the pipe is surcharged or can be filled with water from the blockage to a point where the shock wave is introduced.

6.9.3 Pipes, Fittings and Joints

Pipes, fittings and joints shall comply with the relevant Ethiopian Standards or equivalent and shall be acceptable upon the approval of the Building Official.

SECTION 7

7 STROM WATER DRAINAGE

7.1 Scope

(1) The materials to be used shall be selected to ensure satisfactory service for the life of the installation.

7.2 Materials

(2) Factors to be taken into consideration for compliance with (1) above shall include:

(a) cost,

(b) the nature of the ground and the possibility of chemical attack there from,

(c) the physical and chemical characteristics of the materials, and

(d) the possibility of abrasion by solids in the flow, or of chemical attack of materials.

7.2.1 Standards to be Complied With

(1) Materials and components for storm water drainage should comply with the relevant Ethiopian Standards or equivalent and shall be acceptable on the approval of the Building Official.

7.3 Joints

(1) Gutters and downpipes should be jointed in accordance with good engineering practice.

(2) Manufactures' instructions on the methods of jointing should be strictly following where available.

7.4 Design

7.4.1 General

When designing drainage systems for roofs, paved and unpaved areas, it is normally impracticable to guard against very infrequent, extremely heavy rainfall events. The designer should aim to achieve safe evacuation of floods of 10 year return period within reasonable time.

7.4.2 Run-off

7.4.2.1 Effective Catchment Areas

(1) The effective catchment area of a sloping or vertical surface depending upon the angle of descent of the rain. For purposes of design it may normally be assumed that the rain falls at angle of one unit horizontal to two units vertical, and that its direction is such as to produce the

maximum rate of run-off to each length of gutter; this is the basis of the recommendations described in (2) to (4)

(2) (a) The effective catchment area, A_e, for flat roofs of a freely exposed horizontal surface is equal to the plan area of the surface (see Figure 7.1 (a)).

(b) Where slopping or vertical surface drains to a flat roof, paved or unpaved area, the additional area of catchment should be calculated as described in (3) and (4) below.

(3) (a) The effective catchment area, A_e, for slopping roofs of a freely exposed surface draining to an eaves or a parapet wall gutter is equal to the plan area of the roof plus half its maximum area in elevation (see Figure 7.1 (b). for a valley gutter, one side of the roof will tend to be exposed to the wind and the other side will tend to be sheltered; the method of calculating the effective catchment area is illustrated in Figure 7.1 (c). Run-off from any vertical walls should be allowed for (see (4) below).

(b) The effect of wind can be appreciated by noting that, compared to a horizontal roof of the same plan width, the run-off will be 25% greater if the roof has a slope of one unit vertical to two horizontal, and 50% greater if it has a slope of one unit vertical to one unit horizontal.

(4) (a) Wind-driven rain will cause run-off from walls and other vertical surfaces that are freely exposed to the wind, but where the run-off is to paved area, run-off from vertical surfaces will normally need to be considered only where flooding of the paved area cannot be tolerated.

(b) for a single wall, the effective catchment area, A_e, should be taken as half the exposed vertical area of the wall. Where two or more walls form an angle of bay, the direction of the wind should be assumed to be such that the walls, considered together, present the maximum vertical area to the rain. The method of calculating A_e is illustrated in Figure 7.2. Surrounding walls are of unequal height. In the latter case the value of A_e should be increased by half the area in elevation by which the higher wall exceeds the lower wall.

7.4.2.2 Rate of Run-off

1. Run-off from roofs, paved areas, roofs and vertical surfaces should be calculated assuming that the surfaces are impermeable; that is, run-off coefficient value C is taken to be 1.0. Run-off coefficient values (c) for unpaved areas should be taken from practices conforming to local conditions. C values for some unpaved areas are given in Table 7.1.

2. The rate of run-off Q (in *l/s*) is given by the equation:

$$Q = \frac{CA_e I}{3600} \qquad (7.1)$$

Where,

A_e is the effective catchment area (in m^2),
I is the rainfall intensity (in *mm/h*) for the minimum average recurrence interval in years and time of concentration.

IDF curves covering Ethiopia are given in consecutive Figure 7-3 (A to D). If long-term hourly rainfall data exists for a given location, specific IDF curve shall be used in conjunction with the regional IDF curve.

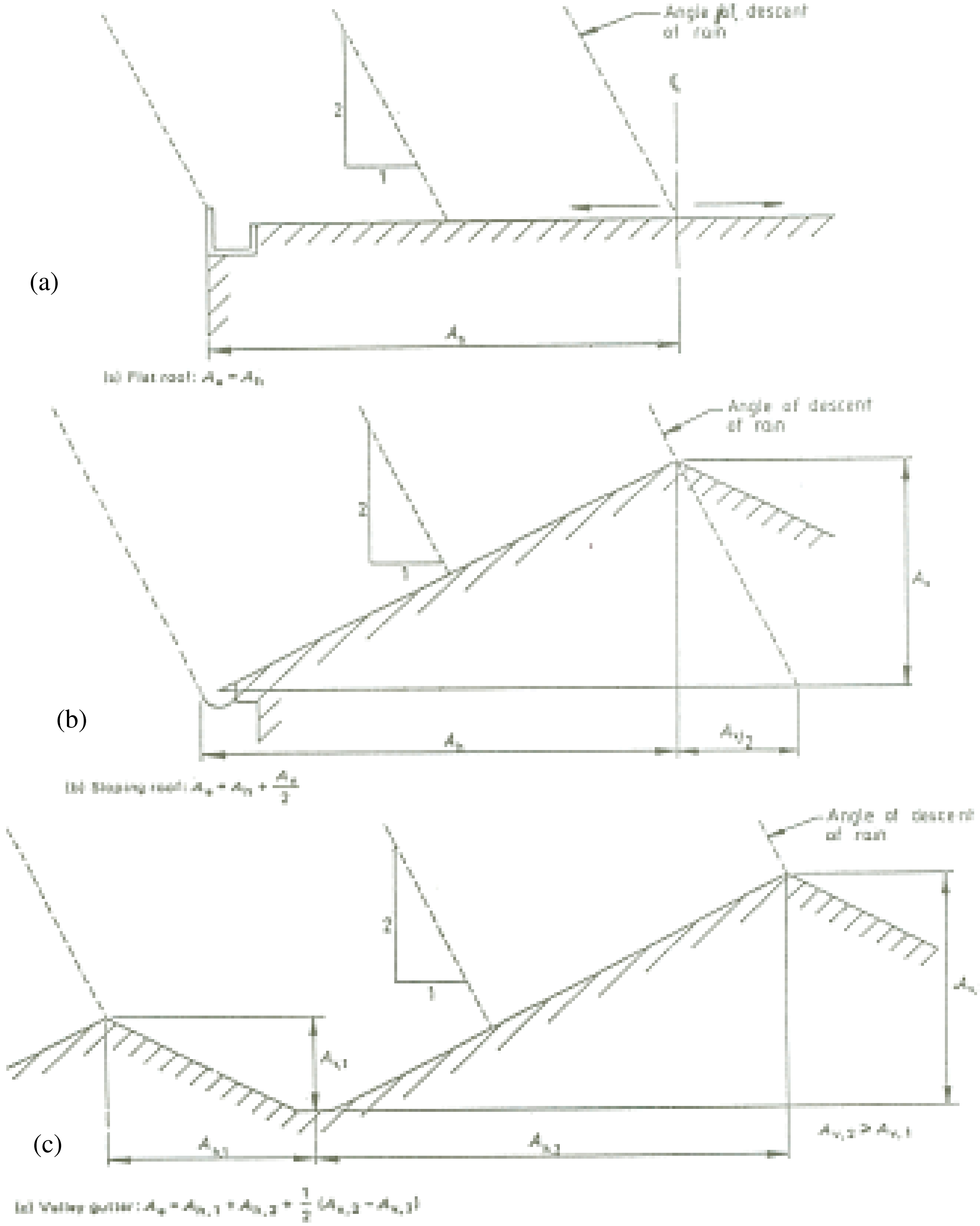
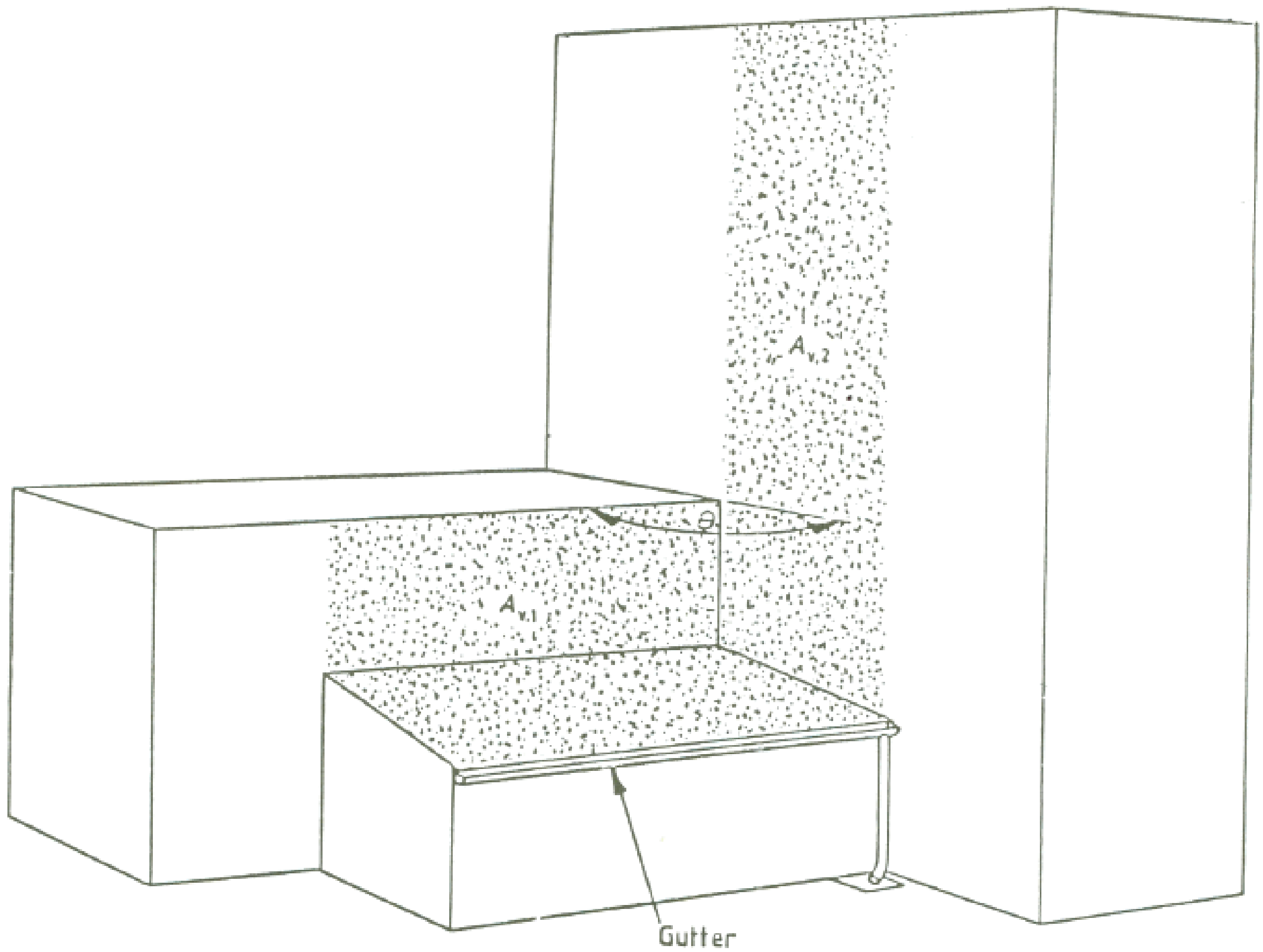


Figure 7-1 Calculation of effective catchment area, Ae, for roofs



$$A_e = \frac{1}{2}\sqrt{(A_{v,1}^2 + A_{v,2}^2 - 2A_{v,1} \cdot A_{v,2} \cos\theta)}$$

where $A_{v,1}$ and $A_{v,2}$ are areas of the vertical walls, as shown, contributing to the flow of the gutter.

Figure 7-2 Calculation of effective catchment area, Ae, for vertical surfaces

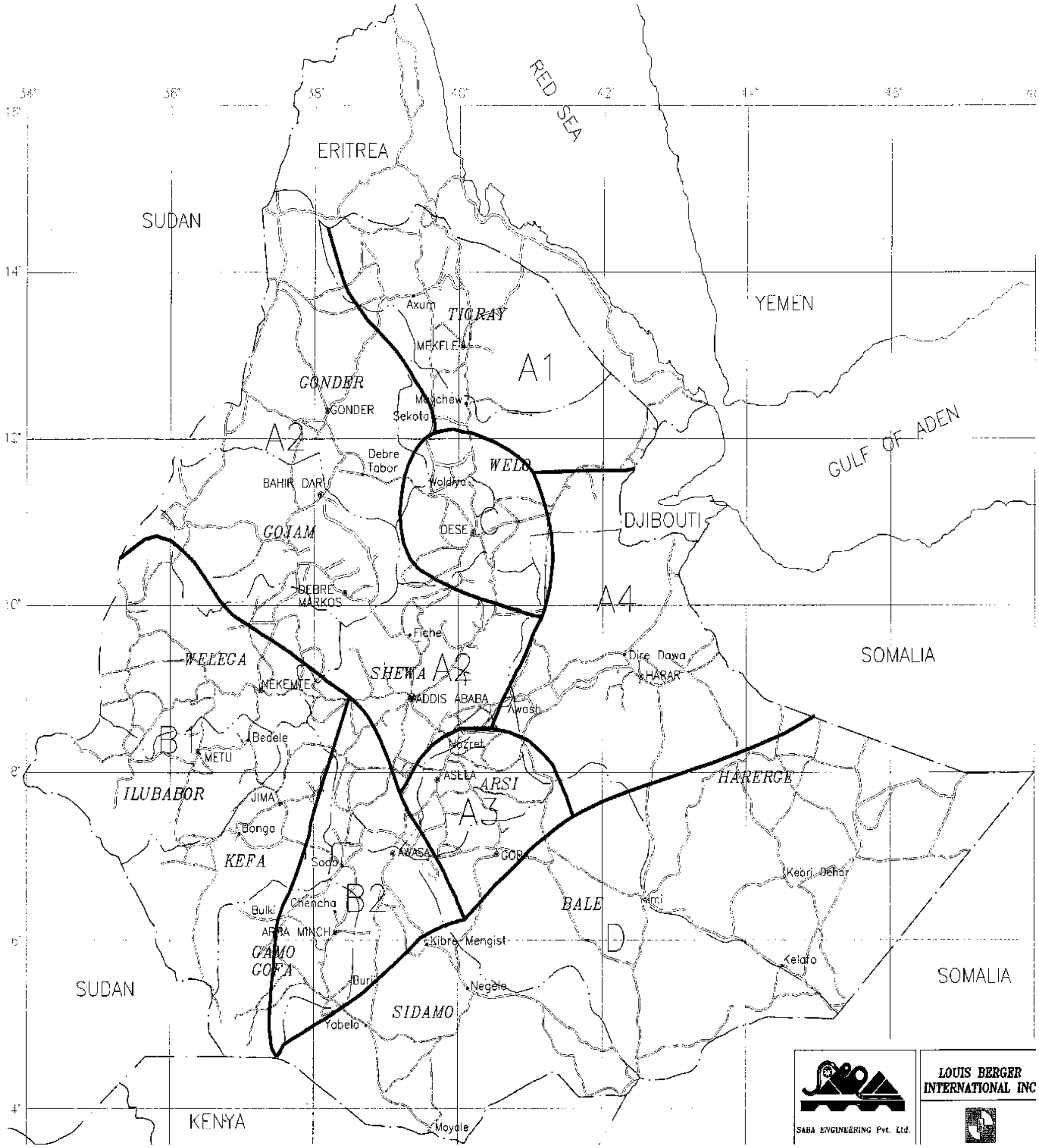
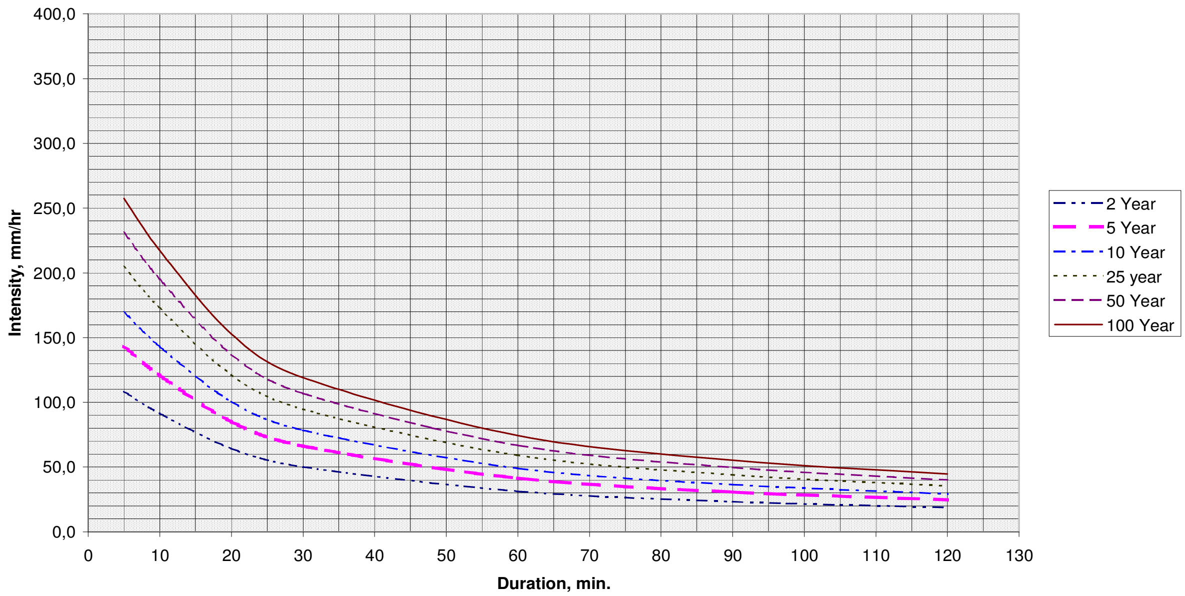


Figure 7-3(a) Rainfall Regions

Note: Rainfall data used in the preparation of this figure have been collected from many Ministry of Water Resources meteorology stations. In the course of the preparation of this manual, they have been subjected to statistical techniques. The results indicate that the country can be divided into the above hydrological regions displaying similar rainfall patterns. The information is subject to review, and future data may indicate the need for a further refinement in both values and regional boundaries.

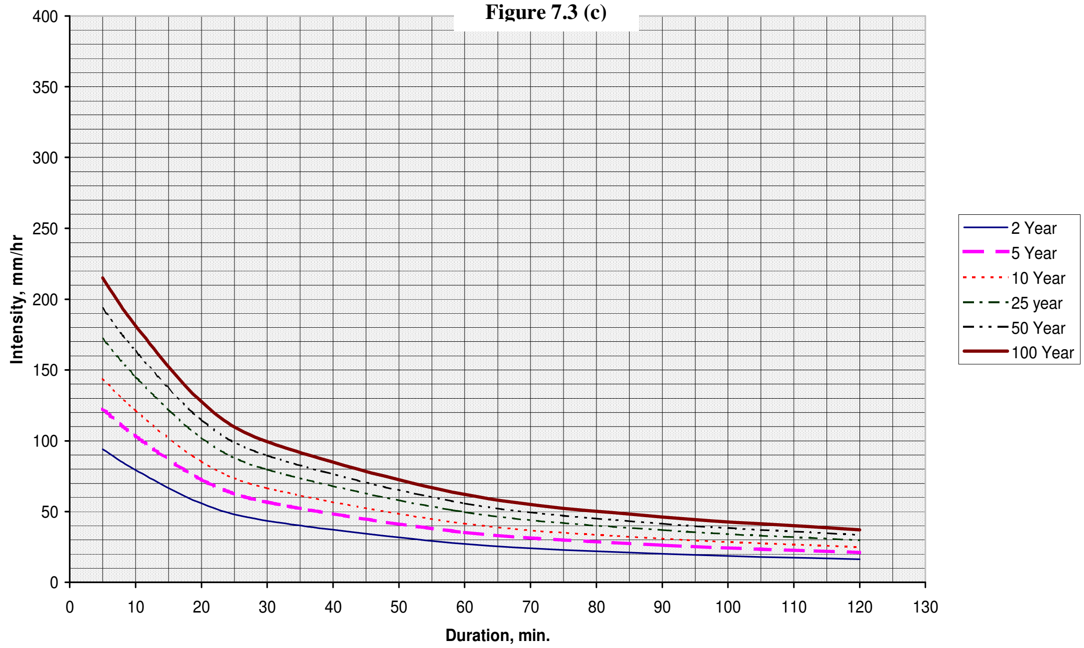
Intensity-Duration-Frequency
Regions A1 & A4

Figure 7.3(b)



Intensity-Duration-Frequency
Regions A2 & A3

Figure 7.3 (c)



Intensity-Duration-Frequency
Regions B, C & D

Figure 7.3(d)

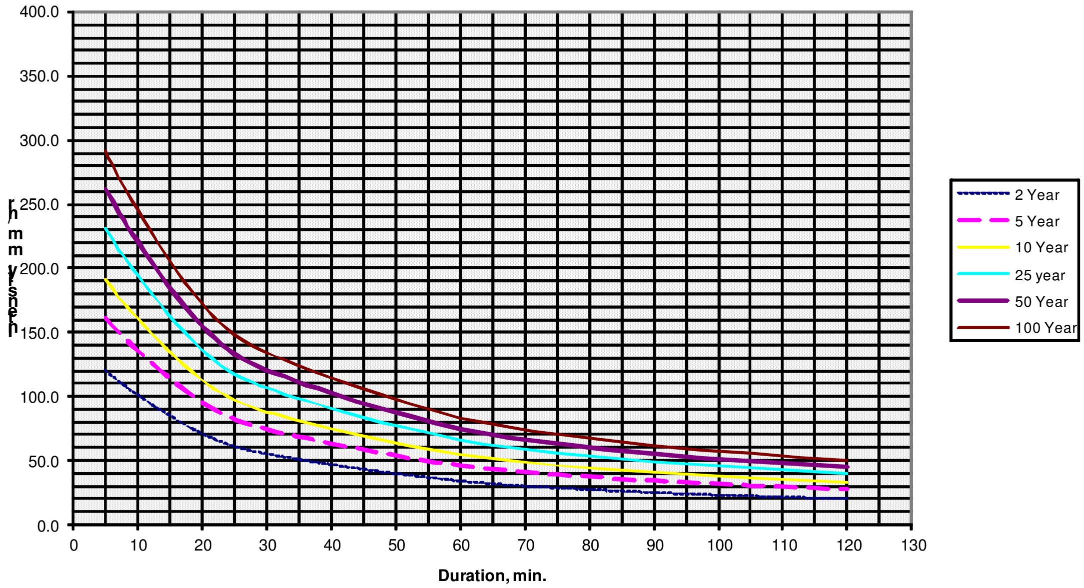


Table 7-1 Recommended Runoff Coefficient C for Various Selected Land Uses

Description of Area	Runoff Coefficients
Business: Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, attached	0.60-0.75
Suburban	0.25-0.40
Residential (0.5 hectare lots or more)	0.30-0.45
Apartment dwelling areas	0.50-0.70
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.40
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Street:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Drives and walks	0.75-0.85
Roofs	0.75-0.95

Source: Hydrology, Federal Highway Administration, HEC No. 19, 1984

7.4.3 Roof Drainage

7.4.3.1 General principles

(1) A roof drainage system generally comprises the following three parts:

(a) The gutter or channel that collects the flow from the roof;

(b) The outlet into which the flow from the gutter or channel discharges;

(c) The pipework (downpipe) that conveys the flow from the outlet to the drainage system.

(2) The three parts of the drainage system in (1) above can be designed separately if the outlet and the pipework (downpipe) are made large enough for the flow to discharge freely from the gutter; this is the basis of the method of design described in 7.4.3.2 through 7.4.3.5. Occasionally, it is necessary to use outlets or pipe work that are smaller than those required by this method. When this occurs, the capacity of the gutter is less than the capacity that it has when it discharges freely; consequently another methods of design becomes (see 7.4.3.2 and Annex G).

(3) Gutters and downpipes may be omitted form a roof at any height provided that is has an area of $6.0m^2$ or less and provided that no roof or other surface drains onto it. Consideration may be given to the omission of gutters and downpipes from tall structures where run-off would be dispersed before reaching the grounds; such run-off should be directed so as to avoid undesirable pattern, staining and splashing of windows.

7.4.3.2 Methods of design

(1) The method of design described subsequently (another method of design satisfactory to the Building Official may also be used) is based on the following assumptions:

- (a) The gutter slope is not steeper than 1 in 350 (i.e, it is normally level). A gutter laid to fall will have a somewhat higher capacity, but this increase should be viewed as an additional factor of safety.
- (b) The gutter has a uniform cross-sectional shape
- (c) The outlets are large enough to allow the gutter to discharge freely.
- (d) The distance between a stop-end and an outlet is less than 50 times the upstream water depth, or the distance between two outlets is less than 100 times the upstream water depth.

(2) Eaves gutters should, wherever possible, be designed to discharge freely. If the length of an eaves gutter exceeds the limits given in (1d) above, it is necessary to reduce its design capacity. Methods of designing gutters that can't discharge freely or that exceed the limits in (1d) above are given in Annex G.

7.4.3.3 Calculation of flow in gutters

(1) (a) After the run-off from roof of a building has been calculated, its direction of flow in the gutter is determined by the position of the outlets. If a length is served by two outlets, the flow will split equally between them even if the flow does not enter the gutter uniformly along its length.

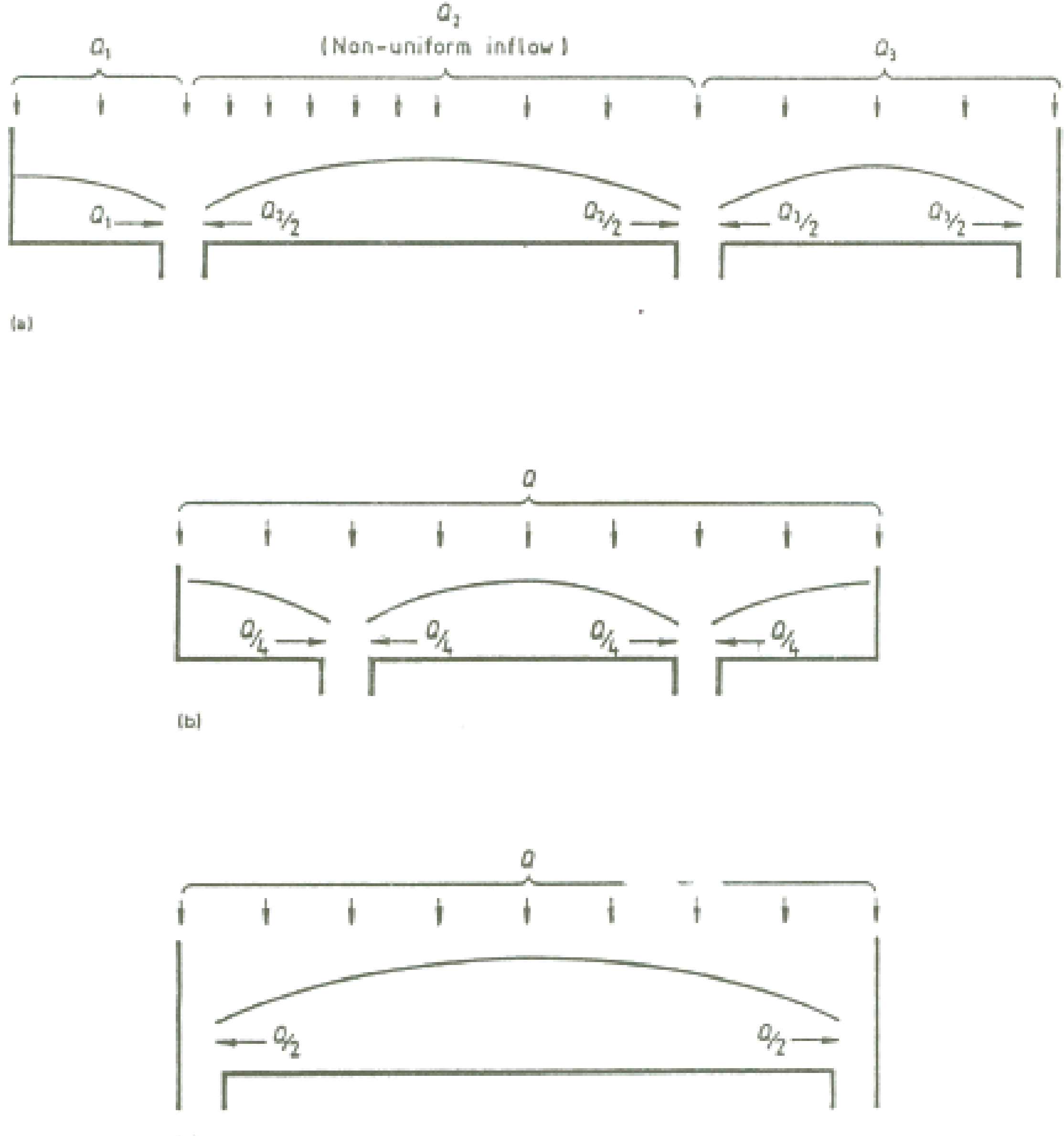
(b) Figure 7.4 (a) shows how the flow at each outlet in a length of gutter can be calculated. If a strong wind blows along a gutter, the flow may be increased in that direction.

(c) Figure 7.4(b) and 7.4(c) show how the capacity of a gutter can be used most efficiently. In Figure 7.4(b), the outlets split the gutter into three sections, of which the middle one collects half the flow and discharges at both ends; if the total flow from the roof is Q, then each section of the gutter needs to have a discharge capacity of Q/4.

(d) Figure 7.4 (c) shows a less efficient arrangement in which the outlets are positioned at the ends of the gutter; in this case, a large gutter is required since each section needs to have a discharge capacity of Q/2.

(2) (a) Although there is an optimum arrangement for the outlets(see (1) above), their number and position will often be determined by the layout of the building or other architectural factors.

(b) If for any reason internal downpipes are fitted, underfloor drainage should be avoided where possible.
(c) Outlets for gutters should be located, where possible, near each angle; i.e, where there is a change in direction of flow**.**



Note. For the same total flow, the gutter in (c) requires twice the capacity of the gutter in (b).

Figure 7-4 Division of flow between gutter outlets

7.4.3.4 Eave, valley, parapet and boundary-wall gutters.

(1) The shape of valley gutters may often be chosen so as to conform to the cross-sectional shape of the roof. A satisfactory shape of valley gutter is obtained if the sides are slopped at the same slope as the roof up to a height that gives the required flow capacity, and if the sides are then turned vertically upward in order to provide the required amount of free-board.

(2) The fall (slope) to which the gutter is laid will depend on structural considerations and on the material used for the gutter or gutter lining. The method of design described in (4) below assumes that the gutter is level; a gutter laid to fall will have a somewhat higher capacity; but this increase should be viewed as an additional factor of safety.

(3) (a) The overall depth of a gutter should be greater than the depth needed to give the design capacity so as to prevent it from being over-topped by splashing or by waves produced by strong winds.

(b) The amount of free-board should be taken as two-fifth of the maximum depth of flow in the gutter, with an upper limit of 75.0mm.

(4) (a) In a level gutter, the depth of flow is greatest at the upstream end and decrease towards the outlet. Subtracting the allowable free-board from the overall depth of the gutter, therefore, gives the design depth of flow at the upstream end γ_u, the discharge that produces the depth γ_u is the design capacity of the gutter. A level gutter attains its maximum capacity when the outlet is large enough to allow the gutter to discharge freely. When this occurs, the depth of the flow in the gutter just upstream of the outlet is equal to the critical depth γ_c.

(b) The ratio of the depth of flow at the upstream end of the gutter, γ_u, to the critical depth at the downstream end γ_c, depends only upon the cross-sectional shape of the gutter provided that the requirement of 7.4.3.2 are met. The effect of flow resistance is normally small so that the depth of the gutter does not affect the value of γ_u / γ_c unless the gutter is longer than the limit given in 7.4.3.2(1d). γ_c can be read from Figure 7.5 once the upstream flow width , B_u, and the sloe width, B_s (see Figure 7.4) of the gutter are determined. The discharge capacity, Q, corresponding to the critical depth, γ_c, can be calculated directly from Equations (G-1) of Annex G if the cross-sectional shape of the gutter is known. The calculated value of Q assumes that the outlet is large enough to allow the gutter to discharge freely. The method of determining the capacity of trapezoidal gutters with restricted discharge is described in G.2, Annex G.

(c) Rectangular and triangular gutters may be considered as special types of trapezoidal gutter and can, therefore, be designed in the same way as trapezoidal gutters.

7.4.3.5 Gutter outlets

(1) (a) Factors affecting the number and position of required outlets are detailed in 7.4.3.3. Two types of gutter outlets may be used. The outlet pipe may either be connected directly to the sole of gutter, or may be connected to a box-receiver into which the flow from the gutter first discharges.

(b) Box-receivers are preferable to outlets in the sole of the gutter because they ensure that the flow discharges freely from the gutter and may allow smaller outlets to be used. The use of box-receivers is recommended for valley, parapet and boundary wall gutters

(c) the design of structural framework should take account of any internal box receivers (see Figure 7.7 (b) or outlets in the sole of the gutter.

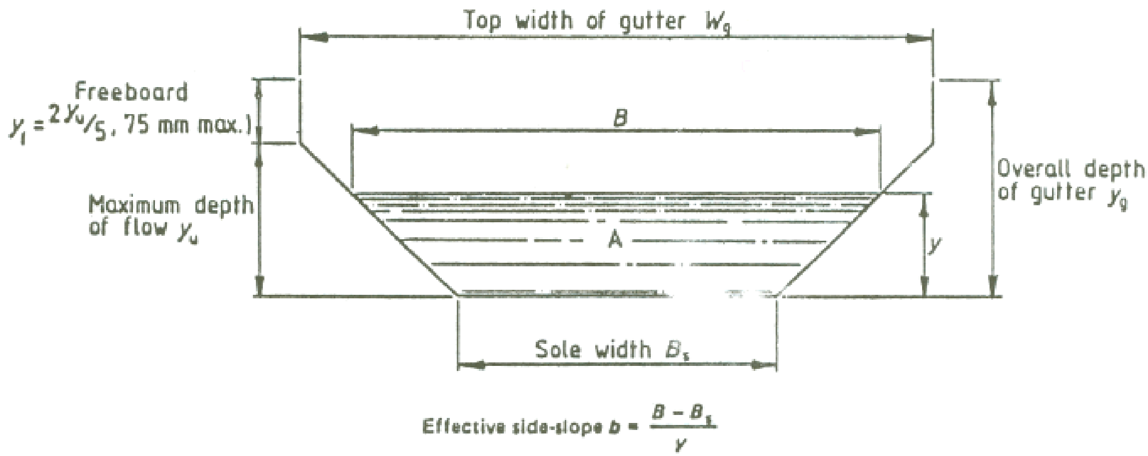


Figure 7-5 Cross-section of a trapezoidal gutter

(2) (a) The dimensions of a box receive need to be larger enough to allow the flow to discharge freely from the gutter to which it is connected. Typical designs for box-receivers are shown in Figure 7.6

(b) The minimum width of the box should not be less than the width of the flow in the gutter at a depth equal of half the overall depth of the gutter, γ_g. If the flow enters the box-receiver from one direction (see Figure 7.7(a)), the length of the box in the direction of flow should be not less than 0.75 γ_g. If the flow enters the box-receiver from opposite directions (see Figure 7.7 (b)); in the later case, the length of the box should be not less than $1.5\gamma_{g.}$ the top of the box should be level with the top of the gutter except where the box is external to the building (see Figure 7.6 (a)); in the latter case, the outer edge of the box may be lowered to act as an emergency overflow.

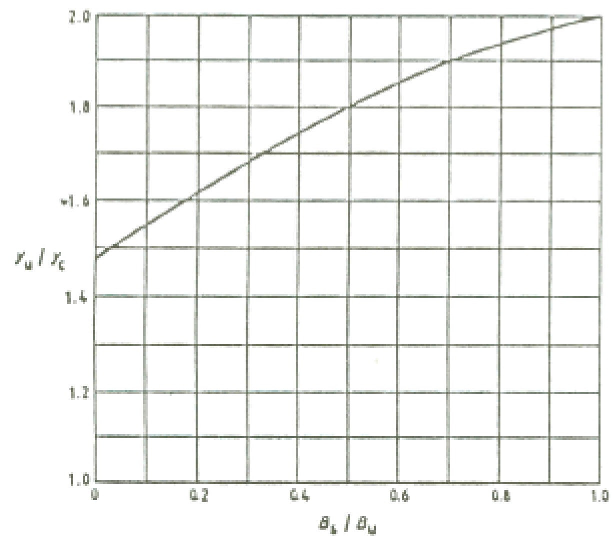
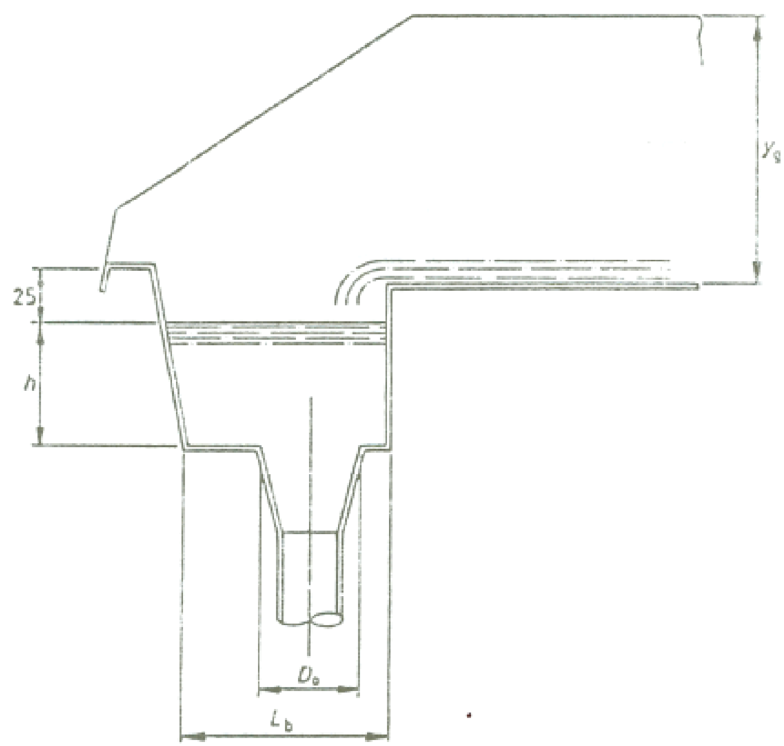
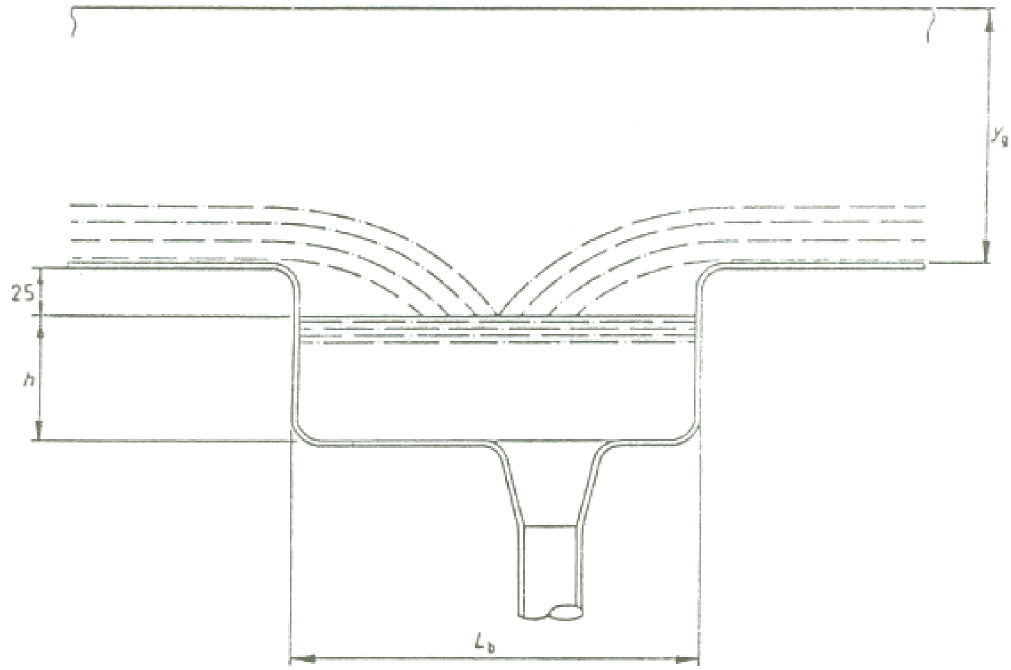


Figure 7-6 Design chart of freely-discharging trapezoidal gutters



(a) External receiver :L_b=075γ_g



(b) Internal receive : L_b- 1.5γ_g

Figure 7-7 Dimension of typical box receivers

(c) The depth of the box below the sole of the gutter should not be less than h+25.0mm, where h is the depth of the water above the outlet. The method of designing such box-receivers is described in G.4, Annex G.

(d) If it is necessary to make the dimensions of a box-receiver smaller than those recommended above the gutter may be prevented from discharging freely.

(3) (a) At small depth of flow, the perimeter of an outlet (outlet in box-receiver) to a downpipe acts as a weir while at large depths of flow the outlet acts as an orifice. An outlet with a rounded edge has a large capacity than a sharp- edged outlet (see Figure 7.8 (a)) having the same size of throat. A suitable type of round-edged circular outlet is shown in Figure 7.8(b); in terms of its discharge capacity, this type of outlet has an effective diameter,D, equal to 0.99 times its top diameter, $D_{o.}$

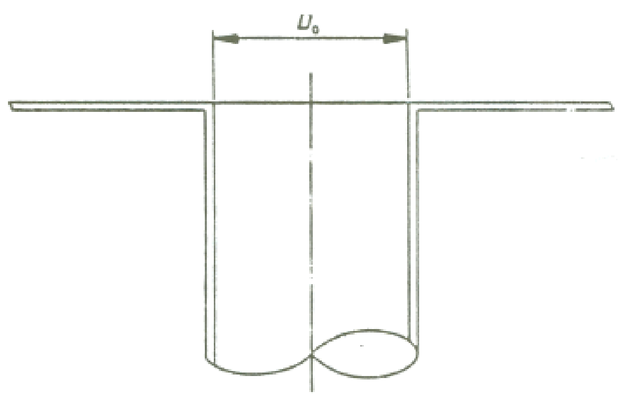
(b) Suitable type of tapered outlets allow smaller size of downpipes to be used without reducing the capacity of the outlet. A tapered outlet with a top diameter D_o will have the same discharge capacity as a sharp-edged outlet of diameter D_o provided that the diameter of the throat is not less than 2/3 D_o and the transition is gradual over a distance not less than Do (see Figure 7.7(c)). Equations relating the depth of water above an outlet, h, to the size of the outlet and the discharge, Q_i, passing through it are given in G.4.1 Annex G. The use of a grating over an outlet will reduce its capacity; the method of designing grated outlets is described in G.4.2, Annex G.

(4) If a downpipe is connected directly to the sole of a valley, parapet or boundary wall gutter, it is necessary to determine whether the outlet (downpipe) is large enough to allow the flow to discharge freely from the gutter. As a rough guide, the effective diameter of an outlet in a rectangular gutter needs to be at least three- quarters of the width of the flow to ensure free discharge. The method of determining whether the gutter discharge freely or not is described in G.4.3. Outlet connected to the sides of gutter are inefficient and their use is not recommended.

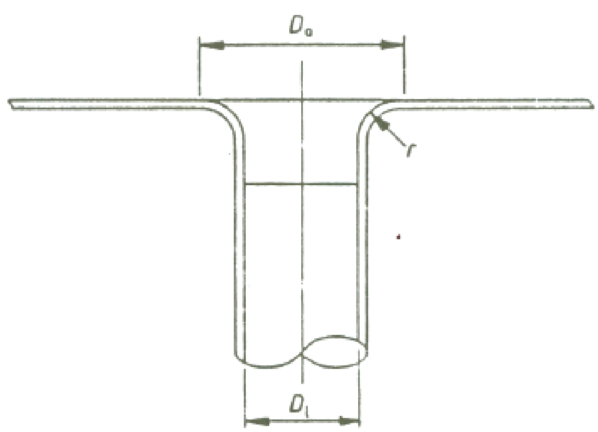
7.4.3.6 Downpipes

(1) (a) The size of circular downpipes (outlets) shall not be less than diameter 60.0mm and that of spouts not less than diameter 50.0mm.

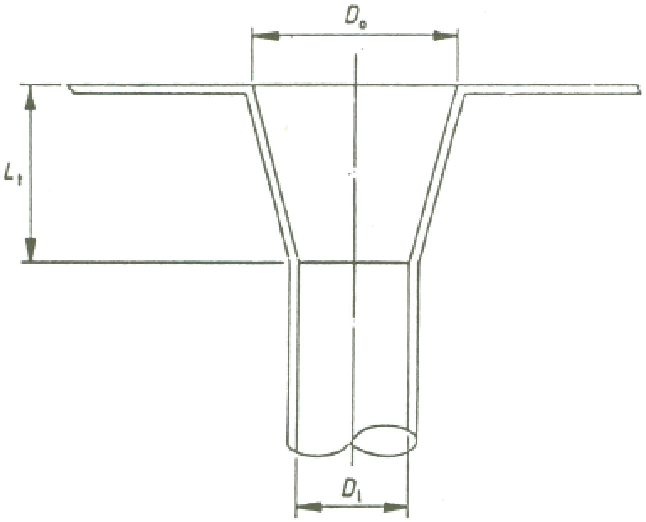
(b) The length of the shorter side of rectangular downpipes (outlets) shall not be less than 60.0mm.



(a) Sharp-edged outlet   Effective diameter $D = D_o$



(b) Round-edged outlet $r = D_o/6$, $D_i = 2D_o/3$ Effective diameter $D = 0.9D_o$



Di > 2Do/3

Figure 7-8 Types of gutter outlets

(2) Tapered outlet (vertical pipes) for valley and parapet wall gutters may be used to reduce the size of the downpipe to not less than two-thirds of the top diameter of the outlets (see 7.4.3.5(3). Pipes sized according to these criteria will tends to flow full so that joints between the downpipes and the gutter or box receivers should be sealed.

(3) (a) Horizontal lengths of pipe should, where possible, be given a small fall to prevent the ponding of water.

(b) Long runs of pipework should be designed according to the standard engineering principles for steady flow in pipes.

(c) All joints on horizontal pipes should be sealed, and access for inspection and rodding should be provided in accordance with 7.5.2(2).

7.4.3.7 Flat roofs

(1) (a) Flat roofs shall be designed to avoid ponding;

(b) Manufactures of roof water-ponding materials shall give recommendations on the minimum fall that should be provide and allowable poundings (allowable depth of water) on roofs during rain storms.

(2) (a) Flat roofs may be drained in two ways:

(i) Towards the outlet edges of the roof.

(ii) Towards channels or outlets within the perimeter of the roof.

(b) Falls are required in both cases of (a) above and can be provided by the construction of the roof of by screeding.

(c) In general, an economic scheme will include few outlets; but the number needed may often be determined by the plan of the roof rather than by the area to be drained.

(3) On a roof laid to falls, a water depth of upto 30mm may be acceptable if it is confined t o relatively small area around the outlets or to a value which may be allowed by manufacturers' of water-roofing materials (see 7.4.3.7(1)), which ever is smaller.

(4) (a) Run-off from a flat roof may be discharged at the edge of the roof into;

(i) An eaves gutter (see figure 7.9(a));
(ii) A chute connected to a hopper head (see Figure 7.9(b)).

(b) The eaves gutters and their outlets should be designed in the same way as in 7.4.3 and 7.4.3.5.

(c) The entrance to a chute acts as a weir and the width that is required can be estimated from Equation (G-6) in G.4.1, Annex G in which L_w is the width of the chute (in mm) and h is the head of water above the invert of the chute.

(5) (a) Run-off from a flat roof may be discharged within the perimeter of the foot into:

(i) A channel formed within or by the roof (see Figure 7.9(d));
(ii) A sump containing an outlet;
(iii) An outlet draining t he roof directl7y (see Figure 7.9 (c)).

(b) Roof channels and their outlets should be designed in the same way as in (4) above.

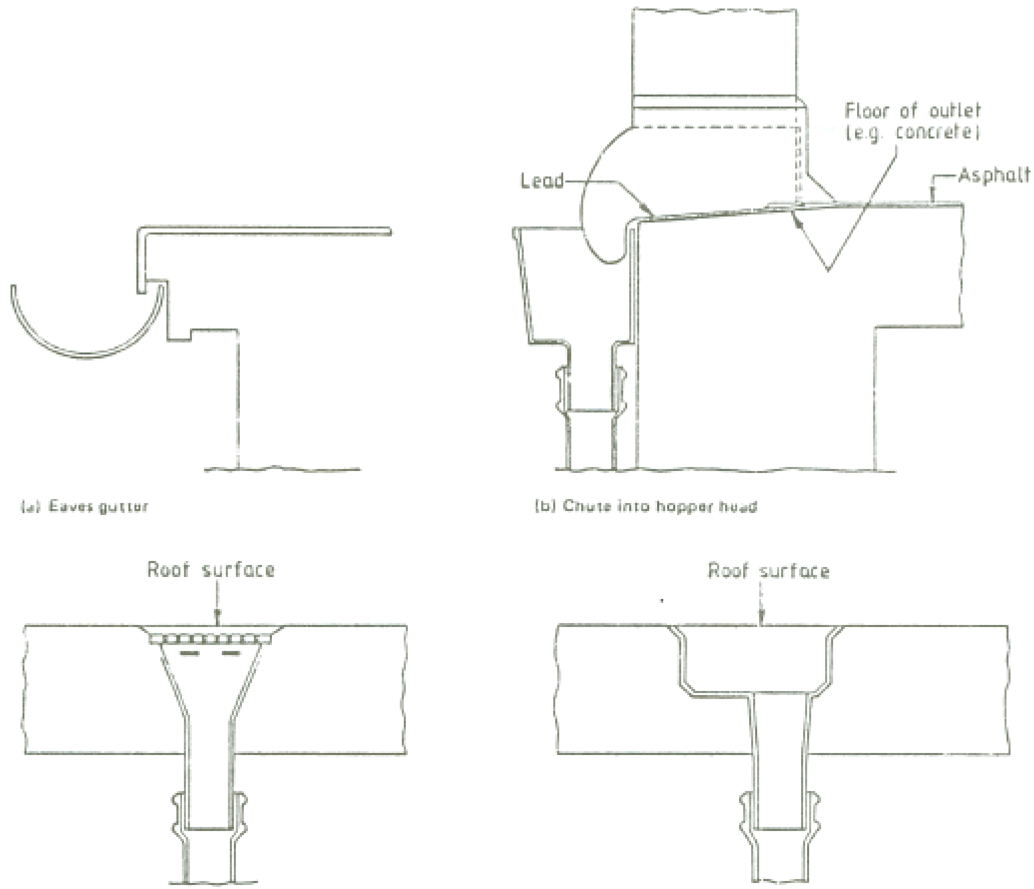
(c) Sumps and roof outlets normally act as weirs, and should be sized so as to limit the depth given in (3) above. The depth of a sump is determined by the capacity of the outlet that drains it, and should be not less than h+25mm where h is the depth of water above the outlets.

(6) The procedure given in (a) through (e) hereunder may be used for determining the required dimensions of a sump:

(a)Locate the position of the sump and calculate the rate of run-off from the catchment areas that is drains. Where possible, the sump should be positioned centrally.

(b) Calculate the total rate of run-off Q (in *l/s*) assuming that the roof is impermeable.

(c)Calculate the length of the wetted perimeter of the sump, L_w, using the appropriate equation in G.4.1, Annex G, after selecting the design depth of water on the roof (see 7.4.3.7(1)). The shape of the sump should be such that the length of each side is approximately proportional to the flow that it receives.



(b) Vertical pipe with bellmouth and grating (d) Vertical pipe either from channel or box –receiver

Figure 7-9 Drainage from flat roofs-Types of outlets

(d) Select a suitable outlet to drain the sump.

(e) Calculate the head *h* required to pass the total discharge, Q, through the outlet using the appropriate equation in E.4.1; if the outlet is covered by grating see G.4.2, Annex G.

(f) The depth of the sump above the level of the outlet should be a minimum of *h*+25mm.

(g) The downpipe connected to the outlet should be designed in accordance with the provisions of 7.4.3.6.

(7) (a) Ungrated roof outlets shall be designed using the appropriate equation in G.4.1, Annex G.
(b) The capacities of grated outlets are best determined experimentally; if suitable measurements are not available, the method described in G.4.2., Annex G, shall be used.

7.4.4 Surface Water Drainage

7.4.4.1 Drainage of unpaved areas

(1) Appurtenances for the drainage of unpaved areas include unlined or lined channels, storm water drains, etc.

(2) Run-off from unpaved areas should be prevented from draining onto paved areas unless appropriate measure is taken to protect the drainage system from blockage.

(3) Design flow rates from unpaved areas should be calculated as described in 7.4.2.2.

(4) The design of drainage appurtenances for unpaved areas should be made in accordance with good engineering practice.

7.4.4.2 Drainage of paved areas

(1) (a) A drainage system for a paved area generally includes:

(i) A paved channel or series of paved channels that collect the run-off from the paved area,
(ii) Inlets or gullies (kerb-inlets or grated inlets (see Figure H-2, ANNEX H) situated at intermediate points along the channels,
(iii) Terminal inlets or terminal gullies set at low points in the paved area or the collecting channel,
(iv) Inlet pits conveniently positioned,
(v) Storm water drains,
(vi) Storm water pits (storm water manhole) conveniently positioned.

(b) the design method of collecting channels and inlets in described in ANNEX H. (Other methods of design satisfactory to the Building Official are also acceptable.)

(2)

(a) The irregular shape of the areas between buildings will often determine the number of inlets that are required rather than the permissible area that can be drained to an inlet. Small paved areas may be drained to central terminal inlets. Larger areas can be split into panels with central terminal inlets, or may more conveniently be drained by collecting channels with intermediate and terminal inlets.
(b) The levels of a paved area should be determined in relation to the levels of the following features:

(c) Water drainage from a paved area should not be allowed to concentrated along the side of the building.

(d) Where the general ground levels might cause concentration of drained water in (c) above, a reverse fall should be applied to a narrow strip around the building so that the water is kept away from the walls.

(e) If a paved area provides access to workshops, underground garages or storage accommodation that are at or below the level of the paved area, channels with gratings or slots should be used and these should be placed at a minimum of 500.0mm away from the building to intercept any water that would otherwise drain into the building.

(f) The drainage system for road entrances and approaches of public roads should be arranged so as to prevent surface water from flowing across the entrance, either to or from a public road.

(g) Gradients of paved areas should be designed to permit quick drainage to collecting channels or inlets.

(3) (a) The general layout of the stormwater drainage system should first be decided and the total area then split into suitable sub-areas. The design flow from each sub-area is then calculated as described in 7.4.2.2.

(b) Collecting channels of shallow triangular cross-section have the same longitudinal slopes and cross falls as the paved surfaces that they drain (see Figure H-2, ANNEX H). channels with other cross-sectional shapes may, however, be used. The discharge capacity of a particular channel will normally be limited by the maximum depth of width of flow that it is convenient to allow. Where pedestrians need to cross collecting channels, the width of the flow should not exceed 500.0mm. The method of calculating the capacity of collecting channels is described in H-2, ANNEX H.

(4) (a) Intermediate inlets (kerb inlets or grated inlets (gully-gratings) are generally used where:

(b) Kerb-inlets generally have a lower capacity than grated inlets of the same length, but are less liable to damage by vehicles. The design of intermediate inlets is given in ANNEX H.

(c) Terminal inlets (terminal gullies) are situated at low points in the paved area or collecting channel. The capacity of a terminal inlet is normally determined by the depth and area of ponded water that can be permitted at the low point. Such inlets should be generously sized as they are more likely to cause flooding than intermediate inlets. The method of determining the capacity terminal inlets is given in H-7, ANNEX H.

(5) Strom water drains

(a)Shall be sized in accordance with the relevant provisions in Section 6,

(b) Shall have a minimum size of 150.00mm diameter.

(6) Stand traps.

(a)Shall be provided to remove contamination, generally and sand or silt, from stormwater prior to discharge to the storm water drainage system.

(b) Shall be adequately sized depending on the use of the area, the type of surface and frequency of cleaning. However, a minimum depth of 500.0mm below the invert of the outlet storm water drain shall be provided.

7.5 Installation

7.5.1 Gutters

(1) Eaves gutters, especially when fixed on rafter brackets, shall be given a fall to allow from any settlement and recommended rate of fall is 1 in 350**.**

(2) Gutters shall be adequately supported so as to prevent sagging and ponding, and care shall be taken that there is no sideways tilt.

7.5.2 Downpipes

(1) (a) Downpipes may fixed by holderbats, etc, screwed or built-in.

(b) All holderbats should be adequately protected against corrosion.

(c) Downpipes that require painting should be fixed at least 30.0mm clear of the building structure using spacers or projecting ears.

(d) Materials for fixing should be selected to avoid electrolytic action,

(2) One or more cleaning eyes (cleanouts) for access and rodding should be provided at appropriate points in horizontal runs of pipe and on long vertical pipes. This is particularly important at the foot of each down pipe and at changes in direction.

(3) It is essential that downpipes are not encased in concrete columns or structural walls and it is important that downpipes in castings or ducts are accessible for maintenance and replacement.

(4) (a) Where there is no alternative to a downpipe discharging on to a lower roof or paved area, a rainwater shoe should be fitted.

(b) Where downpipes discharge on to lower roof, especially onto a flat roof, it is advisable to reinforce the covering of the flat roof at the point where the rainwater shoe discharges onto it because of the excessive localized wear that can occur under such conditions.

7.5.3 Storm Water Drains

(1) Storm water drains shall be laid in accordance with Section 6.5.

(2) Electrical cables, gas pipes, foul drains, water services, etc, installed proximity to storm water drains shall comply with the provisions of Section 6.5

(3) (a) Storm water drains shall be installed in a manner that provides protection against mechanical damage and deformation.

(b) The depth of cover shall be as specified in Section 6.5

(4) The provisions for excavation, bedding and back filling shall be as in Section 6.6

(5) (a) Storm drains shall be joined to each other by means of:

(i) An oblique junction fitting or swept junction at an upstream angle of not greater than 600, all swept in the direction of flow, except for concrete pipes;

(ii) A storm water pit or an inlet pit.

(b) Where storm water drains on grade and a vertical downpipe connect, the upstream angle shall not be greater than 60^0.

7.5.4 Strom Water Pits and Inlets Pits

(1) The design of storm water pits and inlet pits shall be in accordance with the relevant provisions in Section 6.7.

(2) Inlet pits shall be provided with inlets in appropriate locations (see 7.4.4.2.(1)).

(3) Inlets bars or gratings shall be designed and installed to withstand external pressures (e.g. vehicle), and shall be adequately spaced in accordance with good engineering practice.

7.5.5 Inlets

(1) Inlets shall be installed at intermediate and terminal locations (see 7.4.4.2 (1)) to permit the entry of storm water to inlet pits.

(2) Inlets bars or gratings shall be designed and installed to withstand external pressures (e.g. vehicle), and shall be adequately spaced in accordance with good engineering practice.

7.6 Inspection, Testing and Maintenance

7.6.1 Inspection

(1) The work should be visually inspected during installation to check compliance with the specification and design.

(2) On completion of the installation, all aboveground and underground installations should be inspected to ensure that no obstructions are present.

7.6.2 Testing

(1) (a) Each new, repaired or altered section of an internal gutter and/or internal downpipe, when plugged and filled with water to the immediate upstream overflow level for not less than 5.0min, shall be free from leaks.

(b) External downpipes and gutters should be tested as in for the corresponding internal elements in (a) above where necessary.

(2) Each new, repaired, or altered section of a storm water drain shall be subject to either a water test or an air test. The testing method shall be as described in Section 6.9

7.6.3 Maintenance

(1) (a) Gutters, downpipes and gratings should be inspected and thoroughly cleaned before and after every rainy season, or more often if the building is in or near dusty area, or is near to trees, or may be subject to extremes of temperature.

(b) Inlet pits, channels and storm water drains should be inspected and cleaned out regularly. The frequency of inspection and cleaning will need to be based on local experience. Defects should be remedied as soon as possible after being noted.

All ferrous metals require protection against corrosion and, if not supplied with an adequate protective coating, they should be painted.

Section 8

8 SOLID WASTE MANAGEMENT

8.1 General

8.1.1 Scope

(a) Efficient collection and disposal of domestic garbage from a building or activity area is of significant importance to public health and environmental sanitation and, therefore, an essential part of the construction of the built in environment.

(b) The provisions relating to solid waste management given in 8.2 are applicable to wastes in general, and specifically exclude the hazardous chemical wastes and bio-medical waste.

8.1.2 Basic Principles (Reduce/Reuse/Recycle)

(a) Waste reduction is achieved by reusing some waste items, recycling selected materials and composting of green/organic/biodegradable waste. In most of this service providers are involved. However, the impact of waste reduction on collection and disposal services is highly increased when waste is segregated at the source through the people, the waste producers.

(b) **Reduce**: Waste prevention, or "source reduction," means consuming and throwing away less. It includes:

- purchasing durable, long-lasting goods;
- seeking products and packaging that are as free of toxics as possible;
- redesigning products to use less raw material in production, have a longer life, or be used again after its original use.

(c) Source reduction actually prevents the generation of waste in the first place, so it is the most preferred method of waste management and goes a long way toward protecting the environment.

(d) **Reuse**: Reusing items by repairing items, donating items to charity and community groups, or selling items; also reduces waste. Reusing products, when possible, is even better than recycling because the item does not need to be reprocessed before it can be used again.

Ways to Reuse: Reusing plastics, refilling bottles, using cloth napkins or towels, donating old magazines or surplus equipment, especially to schools, reusing boxes, turning empty jars into containers for leftover food, purchasing refillable pens and pencils.

(e) Recycle: Recycling turns materials that would otherwise become waste into valuable resources. It generates a host of environmental, financial, and social benefits.

(f) Materials like glass, metal, plastics, and paper can be collected, separated and sent to facilities that can process them into products.

8.2 Solid Waste Management Systems

In designing a system dealing with collection of domestic garbage for a built premises/community/ environment, the aim shall be to provide speedy and efficient conveyance as an essential objective for design of the system, The various available systems may be employed in accordance with 8.2.1 to 8.2.3, which may be adopted individually or in combination as appropriate in specific situations.

8.2.1 Refuse Chute System

8.2.1.1 General

Refuse chute system is a convenient and safe mode of collection of domestic solid wastes from buildings exceeding 3 storeys. The internal diameter of the chute shall be at least 300 mm. The access to the refuse chute shall be provided from well ventilated and well illuminated common corridor or lobby and preferably it should not be located opposite or adjacent to entry of individual flats or lift.

8.2.1.2 Opening for feeding of refuse chute

Opening, with top or bottom hinged shutters with appropriate lockable latch, shall be provided form convenient accessing of the refuse chute by users.

8.2.1.3 Reuse collection chamber

The collection chamber may be located in ground floor or basement level, provided appropriate arrangement is made for:

(a) drainage of the collection pit by gravity flow to ensure its dryness,

(b) an appropriate ramp access is provided for convenient removal of garbage from the collection pit, and

(c) satisfactory ventilation for escape of gas and odor. The floor of the chamber shall be provided with drainage through a 100 mm diameter trap and screen to prevent any solid matters flowing into the drain and the drain shall be connected to the sewer line. The floor shall be finished with smooth hard surface for convenient cleaning. The height of the collection chamber and vertical clearance under the bottom level of garbage chute shall be such that the garbage trolley can be conveniently placed. The collection chamber shall be provided with appropriate shutter to prevent access of all scavenging animals like the cattle, dogs, cats, rats, etc.

8.2.1.4 Material for chute

The chute may be of masonry or suitable non-corrosive material. Further the material should be rigid with smooth internal finish, high ductility and alkali/acid resistant properties.

8.2.1.5 Size of trolley

The size of the garbage trolley shall be adequate for the daily quantity of garbage from a chute. For working out quantity of garbage, a standard of approximately 0.75 kg/person may be taken.

8.2.1.6 Dumb-Waiter

In high rise buildings with more than 8 storeys, electrically operated dumb-waiters may be used for carrying domestic garbage in packets or closed containers. For handling of garbage by dumb-waiters in a building, a garbage chamber shall have to provide either at ground floor or basement level and the provisions of garbage collection chamber for chute as given in 8.2.2 shall apply.

8.2.1.7 Shutters for dumb-waiter

The shutters for dumb-waiter and garbage collection chamber shall be provided with shutters with same consideration as in the case of garbage chute. However, the dumb-waiter shall be made child-proof.

8.2.1.8 Sorting of garbage to remove toxic matters from garbage

Before feeding the garbage to compost pits the following objects need to be removed:

1. inert matters like glass, metals, etc;
2. chemicals, medicines, batteries of any kind;
3. polythene and plastic materials; and
4. any other non-biodegradable material.

These separated items shall be handled separately, and may be scrapped or recycled, etc as appropriate.

8.2.2 Treatment by Vermi-Composting

Vermi-compost treatment shall be provided to the organic wastes in composting pits located in shade. The pits shall be used to receive the garbage in a predetermined (periodic) cyclic order. (For example 5 pits to receive garbage in 5 days and these 5 pits together accepting daily load of garbage.) The gross area of the composting pits may be about 0.1 m^2 per person.

(a) The site for vermi-comporting shall be enclosed from all sides with appropriate fencing (for keeping scavenging animals away) and provided with a small door for accessing the enclosed premises.

(b) Composting pits shall be constructed either under the shade of trees (except New tree) or created by sheeting or shade net so as to keep the pits under shade. The pits shall be easily accessed for convenient shifting of garbage from trolleys carrying garbage.

(c) The composting pits shall be made in a manner that the pits do not have the risk of inundation by water. This may be achieved by appropriately raising the base level of the pit and providing weep holes from sides. Height of side walls of compost pits need to be 0.6 m to 0.75 m high. The bottom of the pit without any lining is preferred.

(d) Initiation of composting pits shall be done by providing a 75 mm thick layer of cow dung (fresh or partially decomposed) spreading 1 kg of vermin-compost and covering it with 75 mm to 100 mm thick layer of dry leaves/grass, etc and sprinkling of water and allowing to decompose naturally for about 10 to 15 days.

(e) Sorted garbage free from inert and toxic matters shall be applied in the composting pit in layers of 75 mm and spread, and covered with a layer of 75 mm thick dry leaves followed by sprinkling of water.

(f) The compost may be removed from the bottom of the compost pit after intervals of 3 to 6 months. The compost so made may be used in appropriate horticultural and related applications.

8.3 Refuse Chute System

8.3.1 Purpose

Refuse chute system is provided in multistoried buildings for transporting and collecting in a sanitary way the refuse from floors at different heights. The refuse is received from the successive floor through the inlets located on the vertical system of pipes that convey refuse through it and discharge it into the collecting chamber from where the refuse is cleared at suitable intervals.

8.3.2 Components

This system has got three functionally important components, namely, the chutes, the inlet hopper and the collection chamber.

(a)The chute may be carried through service shafts meant for carrying drainage pipes. However, the location shall be mostly determined by the position of the inlet hopper and the collecting chamber that is most convenient for the user. It should also be considered to locate the chute away from living rooms in order to avoid noise and smell nuisance.

(b) In individual chute system, the inlet hopper shall be located in the passage near the kitchen and in the common chute system towards the end of the common passage. Natural ventilation should be adequate to prevent any possible odor nuisance. There should be adequate lighting at this location. For ground floor (floor 1), the inlet hopper may be placed at a higher level and a flight of steps maybe provided for using the same.

(c)The collection chamber shall be situated at ground level.

8.3.3 Requirements

Requirements in regard to the design and construction of refuse chute system shall be in accordance with good practice (See Annex I).

ANNEXES

ANNEX A

Application Form for Temporary/Permanent Supply of Water/for Additions and/or Alterations for Supply of Water

I/We . . . . hereby make application to the* …. . . . . for the temporary/ permanent supply of water for the following additions and/or aerations to the water supply requirements and water fittings at the premises . . . .
City.................. Sub-City . . . . District………………..House No………………..
For the purpose described below and agreed to pay such charges as the Authority may from time-to-time be entitled to make and to conform to all their byelaws and regulations . . . . licensed plumber, has been instructed by me/us to carry out the plumbing work.
Description of the premise: ....
Purpose for which water is required: ....
The connection/connections taken by me/us for temporary use, shall not be used by me/us for permanent supply unless such a permission is granted to me/us in writing by the Authority.
I/We hereby undertake to give the* . . . . due notice of any additions or alterations to the above mentioned supply which I/we may desire to make.
My/Our requirements of water supply areas under:

(a) I/We request that one connection be granted for the whole of the premises.
(b) I/We request that separate connections may be granted for each floor and I/we undertake to pay the cost of the separate connections.
(c) My/Our probable requirements for trade purpose are . . . . liters per day and for domestic purposes are . .. .liters per day.
(d) Our existing supply is . . . .liters per day. Our additional requirement of supply is . . . .liters per day.
(e) The details as regards proposed additions and alterations in fittings are as follows:
. . . .
. . . .

Signature of the licensed plumber ....
Name and address of the licensed plumber
.... ……
……………………………………………........
Date .... ………….

Signature of the applicant.............................
Name and address of the applicant
……………………. . . . .
……………………………………………..
Date ....

NOTES
1 Please strike out whatever is not applicable.
2 The application should be signed by the owner of the premises or his constituted attorney and shall be countersigned by the licensed plumber.
* Insert here the name of the Authority.

ANNEX B

Form for Licenced Plumber's Completion Certificate

Certified that I/we have completed the plumbing work of water connection No …................. for the premises as detailed below. This may be inspected and connection given.
City......................Sub-City ....District……………….House No…………………
Existing water connection No. (if any) ....
Owned by: ....
Owner's address: ....
....
Applicant's full name: ....
Dated ....
Address ....
Situation ....
Size of main ....on ....
Street..
Where main is situated ....
Size of service pipe ....
Size of ferrule ....
No. of taps .... No. of closets..
No. of other fittings and appliances ....
Road cutting and repairing fee ....

Paid Eth. Birr .... (Receipt No……………… dated……………)
(receipt enclosed)

Signature of the licensed plumber ....
Name and address of the licensed plumber ....
……………………………………………………………………………………………………

The Authority's Report

Certified that the communication and distribution pipes and all water fittings have been laid, applied and executed in accordance with the provisions of bye-laws, and satisfactory arrangements have been made for draining off waste water.
Connection will be made on...

Date......................... The Authority...
…………………………………………………………………
…………………………………………………………………..
…………………………………………………………………..

ANNEX C

Application for Drainage of Premises

I/We hereby make application to the * ....
for permission to drain the premises .... City..
Sub-City………………..District…………………..
House No..Road/Street known as ....
……………………………………………………………………………………………………..
The sanitary arrangement and drains of the said premises are shown in the accompanying plans and a description of the specification of the work/material used is also appended (Annex D).
I/We undertake to carryout the work in accordance with
EBCS 9 Plumbing Services, Section on Water Supply, Drainage and Sanitation' of the Code.

Signature of the licensed plumber………………	Signature of the owner …………
Name and address of the licensed plumber……..	Name and address …………………
....	………………………………………..
....	…..……………………………………
Date	Date ....

NOTE – The application should be signed by the owner of the premises and shall be countersigned by the licensed plumber.
* Insert the name of the Authority.

ANNEX D

Form for Detailed Description of Work and Specification of Material

1) Separation of rain-water and foul water ....
2) Rain-water drains, curbs and points of discharge ....
3) Rain-water gutters, pipes or spouts where discharging ....
4) Open-full-water drains, materials, sizes, curbs and other means places, verandahs, latrines
5) Silt-catcher and grating, size and position ... .
6) Drains ....
   a) Main sewage drains: Fall ....
      Size ....
   b) Branch drains: Fall ....
      Size ....
   c) Materials..
   d) Method of jointing.....................................
7) Bedding of pipes:
   a) Method of bedding ....
   b) Thickness and width of beds of concrete…………………………………………
   c) Thickness of concrete round pipes ....
8) Protection of drain laid under wall ....
9) Traps description and interceptor:
   a) Lavatory waste pipes ....
   b) Bath waste pipes ....
   c) Sink ....
   d) Gully-traps ....
   e) Water-closet traps ....
   f) Grease traps ....
   g) Slope sink ....
   h) Urinal ....
   i) Others ....`
10) Manholes and inspection chambers:
   a) Thickness of walls ....
   b) Description of bricks ....
   c) Description of rendering ....
   d) Description of invert channels ....
   e) Depth of chambers ....
   f) Size and description of cover and manner of fixing ....
11) Ventilation of drain:

a) Position-Height above nearest ground level ....
b) Outlet shaft position of terminal at top...... ....

12) Soil pipe, waste pipe and ventilating pipe connections:

a) Lead and iron pipes ....
b) Lead pipe of trap with cast iron pipe ....
c) Stoneware pipe or trap with lead pipe ....
d) Lead soil pipe or trap with stoneware pipe or trap ....
e) Cast iron pipe with stoneware drain ....
f) Stoneware trap with cast iron soil pipe..

13) Ventilation of water-closet trap sink, lavatory and other traps material and supports.

14) Water-closets (apartments):

a)
   i) At or above ground level ....
   ii) Approached from ....
   iii) Floor material ....
   iv) Floor fall towards door ....
   v) Size of window opening in wall made to open ....
   vi) Position of same ....
   vii) Means of constant ventilation .. ..
   viii) Position of same .. ..

b) Water-closet apparatus:
   i) Description of pan, basin, etc. ....
   ii) Kind ....
   iii) Flushing cistern ....
   iv) Material of flushing pipe ....
   v) Internal diameter……………………
   vi) Union with basin ....

15) Sanitary fittings, water storage tank, etc:

a) Number and description of sanitary fittings in room and rooms in which theyare to be installed ....
b) Capacity and position of water storage tanks ....
c) Size and number of draw off taps and whether taken off storage tanks or direct from main supply ....
d) Details of draw off taps, that is, whether they are of plain screw down pattern or 'waste not' and description of any other sanitary work to be carried out not included under above headings . ...

16) Depth of sewer below surface of street. ... .

17) Level of invert of house drain at point of junction:

a) with sewer .. ..
b) Level of invert of sewer at point of junction with house drain .. ..

c) Distance of nearest manhole on sewer from the point at which the drain leaves the premises .. ..

18) Schedule of pipes:

Description of Pipe/Drain Materials Diameter Weight Method of Jointing

a) Sub-soil drains
b) Main sewage drains
c) Branch sewage drains
d) Soil pipes
e) Ventilating pipes other than soil pipes
f) Waste pipes
g) Rain-water pipes
h) Anti-syphon pipes

Date ....

Signature of the licensed plumber ....
Name and address of the licensed plumber ....
....
....

ANNEX E

Form for Licenced Plumber's Completion Certificate

Certified that I/we have completed the plumbing work of drainage and sanitation system for the premises as detailed below. This may be inspected, approved and connection given.
City ....Sub-City……………..District…………….House No………….
Details of work:
…..
....
....

The work was sanctioned by the Authority*..

Signature of the owner …………	Signature of the licensed plumber ....
Name and address	Name and address of the licensed plumber……………….
……………………………………	……………………………………………………………………
……………………………………	……………………………………………………………………
Date	Date ....

The Authority's Report

Certified that the plumbing work of drainage and sanitation system for the premises, have been laid, applied, executed in accordance with EBCS-9: Plumbing Services of Buildings.
Drainage connection to the main sewer will be made on ....

Date ....

The Authority
..……………………...
....
....
....

* Insert the name of the Authority.

ANNEX F

Percolation Test

To determine the area of land required (for subsoil infiltration of septic tank effluent) a percolation test is essential. The following method should be adopted for this purpose.

Excavate a hole 300.0mm square to a depth 250.0mm below the proposed invert level of the land drain. Where deep drains are necessary, the hole should conform to this shape at the bottom but may be enlarged above the 250.0mm level to enable safe excavation to be carried out. Fill the 300mm square section of the hole to a depth of at least 250.0mm with water and allow it to seep away overnight. Next day, refill the test section with water to a depth of at least 250.0mm and observe the time, in seconds, for the water to seep away completely.

Divide this by the depth in millimeters of water placed in the hole. The result gives the average time required for the water to drop 1.0mm. The test should not be taken during abnormal conditions such as heavy rain and severe drought. Carry out the test at least three times and take the average.

Where deep excavations are necessary, a modified test procedure may be adopted using a 300.0mm earth auger. Bore the test hole vertically to the appropriate depth taking care to remove all loose debris.

Make water level observation referring to fixed datum using a dip stick or some suitable alternative water-level indicator.

The value found in this way is called the percolation value of the soil (v_p in seconds) and can be used to determine the area of drainage trench floors (walls) required to disperse effluents.

If the percolation value exceeds 140.0s, the soil is not suitable for drain fields. From 140.0s to 100.0s (about 10.0hr to 7.0hr to fall 250.0mm), underdrains are desirable.

ANNEX G

Supplementary Design Method for Roof Drainage

G.1 Capacity of Freely Discharging Gutters

If a lever gutter discharges freely, the depth of flow at the downstream end is equal to the critical depth γ_c. (see 7.4.3.4(4), Section 7. The relationship between discharge, Q (in l/s, and the critical depth is given by the equation.

$$Q = 9.90x10^{-5} \left(\frac{A_c^3}{B_c}\right)^{1/2} \qquad \text{(G-1)}$$

Where

A_c is the cross sectional area (in mm2) corresponding to the critical depth γ_c
A_c is the width (in mm) corresponding to the critical depth γ_c

G.2 Design of Gutters with Restricted Discharge

A level gutter will not discharge freely if the outlet produces a depth of flow at the downstream end of the gutter, γ_c that is greater than the critical depth, γ_c. The capacity of a gutter with restricted discharge will be lower than that of a similar gutter that discharges freely.

Flow conditions at the downstream end of a gutter can be expressed in terms of dimensionless Froude Number, F_o, defined by the equation;

$$F_0 = 1.010X10^5 \left(\frac{B_0 Q^2}{A_0^3}\right)^{\frac{1}{2}} \qquad \text{(G-2)}$$

Where

Q is the discharge (in *l/s*) in the gutter;

A_o is the cross-sectional area (in mm^2) corresponding to the depth γ_o at the outlet (calculated from G.4);

B_o is the surface width of flow (in *mm*) corresponding to the depth γ_c at the outlet (calculated from G.4).

If $F_o = 1$, the depth $\gamma_c = \gamma_c$ and the gutter discharges freely.

If *Fo < 1,* the depth γ_c is greater than the critical depth γ_c and the discharge of the gutter is restricted.

To find the depth of flow γ_c at the upstream and of the gutter, calculate F_0 from Equation G-2, calculated B_s/B_o (where B_s is the sole width of the gutter) and use Figure G-1 to find the value of γ_u/γ_o from which γ_u can be determined.

G-3 Resistance Effects in Long Gutters

Flow resistance causes the depth of flow at the upstream end of the gutter to be somewhat greater than the value of γ_u calculated in G.1 and G.2. As an approximate guide, the increase in the upstream depth of flow due to friction will be less than 5% if the length of the gutter is less than 50 times its upstream water depth. The increase in water depth can be estimated as follows:

a) Calculate the Froude number F_o, from Equation 2 at the downstream end of the gutter. If $F_o \geq 1$, the gutter discharges freely; if $F_o < 1$, the discharge is restricted.
b) Calculate the value of the ratio of $L_g/\gamma_{d,}$ where Lg is the length of the gutter (measured from the outlet to the point at which the maximum depth of flow occurs), and Y_d is the depth of flow at the downstream end.
c) Estimate from Figure G-2 the percentage increases x, in the upstream depth of flow. The depth Y_{uf} at the upstream end taking into account the effect of friction is given by the equation:

$$Y_{uf} = Y_u \left(1 - \frac{x}{100}\right) \qquad \text{(G-3)}$$

The effect of resistance can be neglected if the value of x is found to be less than 5%.

The curves in Figure G-2 are based on a Manning roughness coefficient of n=0.015 in small gutters and n = 0.20 in large gutters.

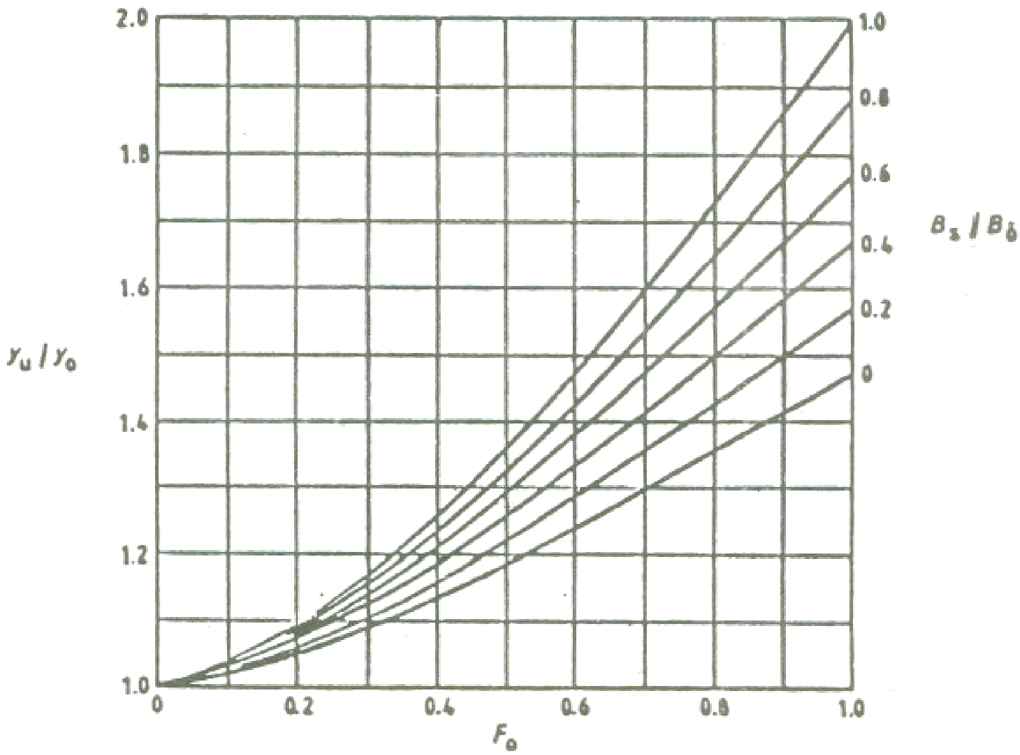


Figure G.1 Design chart for trapezoidal gutters with restricted discharge

G.4 Design of Outlets to Down pipes

G.4.1 Outlets to box receivers

At small depths of flow, an outlet acts as a weir and the flow is controlled by the wetted perimeter of the outlet. At larger depths, the outlet acts as an orifice and the flow is controlled by the plan area of the outlet.

If the flow at a circular outlet is of weir type:

$$Q_i = \frac{Dh^{1.5}}{7500} \text{ for } h \leq D/2 \qquad \text{(G-4)}$$

and if it is of orifice type;

$$Q_i = \frac{D^2 h^{0.5}}{15000} \text{ for } h > D/2 \qquad \text{(G-5)}$$

Where,

Q_i is the total flow (in *l/s*) entering the outlet;

D is the effective diameter of the outlet (in *mm*);

h is t he head (in *mm*) above the top of the outlet.

The effective diameter, D, for a sharp-edged outlet is equal to the top diameter , Do (see Figure 7.7, Section 7); for a round-edged outlet of the types shown in figure 7.7, D= 0.9Do; for a tapered outlet of the type shown in Figure 7.7, D =Do.

The behavior of rectangular outlets is similar to that of circular outlets. If the flow at a sharp-edged outlet is of weir type:

$$Q_i = \frac{L_w h^{1.5}}{24000} \qquad \text{(G-6)}$$

And if it is of orifice type:

$$Q_i = \frac{A_i h^{0.5}}{12000} \qquad \text{(G-7)}$$

Where,

L_w is the length of the perimeter (in mm) along which flow enter the outlet;

A_i is the plan area (in mm^2) of the outlet.

A A transition from weir-type to orificial type for occurs when the head exceeds the value of $h = 2Ai/Lw$

G.4.2 Grated outlets

The capacities of grated for box receivers and flat roofs are best determined experimentally. Where measurements are not available, their capacity may be determined from Equations (G-6) and (G-7. If the outlet acts as a weir, the required value of L_w in Equation (G-6) is the total length of the openings measured around the perimeter of the outlet. If the outlet acts as an orifice, the value of A_i in Equation (G-7) is the total area of the openings that are submerged by the flow; and h is the depth of water above the level of the openings.

G.4.3 Outlets in gutters

Flow at an outlet in the sole of a gutter may be either of a weir-type or of orifice-type. The capacity of an outlet in the sole of a gutter can be calculated from the equations for outlets in box-receivers (see G.4.1).

In order to determine whether a gutter will discharge freely, it is necessary to compare the head, *h*, at the outlet with the corresponding value of critical depth, Y_c, in the gutter (found from 7.4.3.4). If an outlet receives unequal flows from two or more direction, it is necessary to calculate separate values of critical depth for each length of gutter. If the head at the outlet, h, less than the critical depth Yc, the length of gutter will discharge freely; if h is greater than Y_c, the discharge of the gutter will be restricted, and the depth of the flow at the downstream end of the gutter, Y_o, will be equal to the value of h (see G.2).

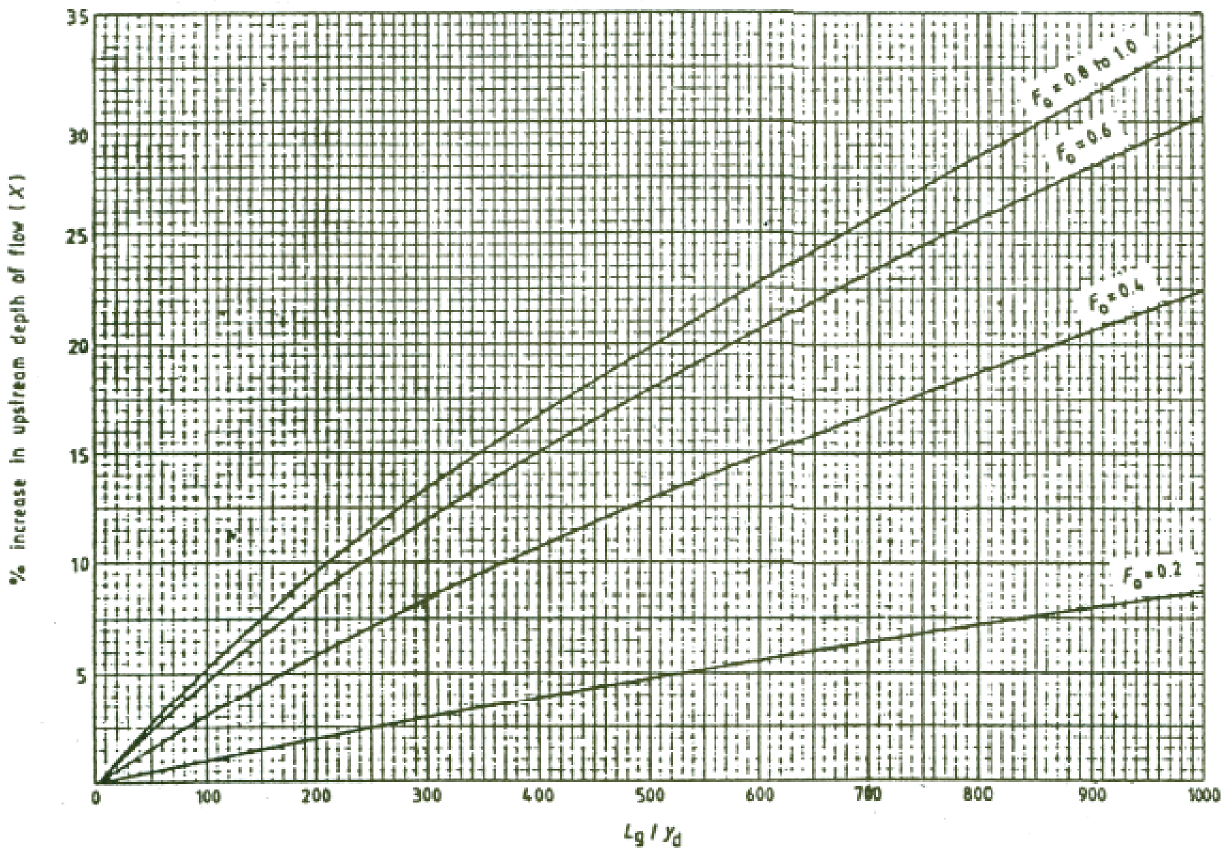


Figure G.2 Effect of resistance in level gutters

Flow conditions at outlets in gutters are complex, and the above procedure contain several simplifying assumptions. More economic design may result from the use of experimental measurements or a more accurate method of calculation.

ANNEX H

Spacing of Inlets for Paved Areas

H.1 General

The spacing of inlets depends upon two separate quantities the capacity of the collecting channel and the capacity of the inlet.

The capacity of a collecting channel is calculated using the Manning equation, Equation (H-1). The capacity of the inlet is calculated using a semi-theoretical method which relates its capacity to its geometry and is supported by a large number of experimental measurements.

H.2 Flow in Collecting Channel

H.2.1 Capacity of channel

The depth of flow in the channel is assumed to be controlled by its hydraulic resistance, and the Manning equation is used to relate the depth of flow, Y, to discharge, Q. For a channel of arbitrary cross-sectional shape, the Manning equation is:

$$Q = \frac{A^{5/3}}{P^{2/3}} \times \frac{S^{1/2}}{n} \qquad \text{(H-1)}$$

Where

A is the cross-sectional area of the flow [mm^2];
P is the wetted perimeter [mm],
s is the longitudinal slope of the channel,
n is Manning's roughness coefficient of the channel.

For channels of shallow triangular cross section, Equation (H-1 may be approximated by:

$$Q = 3.0 \times 10^{-6}\, CY^{8/3} \qquad \text{(H-2)}$$

C is called a channel criterion and is constant for a particular channel since it only depends upon the geometry and roughness of the channel. The factor 3.0x106 assumes that Q is in litres per second and Y in millimeters. The quantity b is the effective side shape of the triangular channel and is defined in Figure H-1. Values of Mannings n for channels with different surfaces are given in Table H-1.

H.2.2 Inlet criterion (Gully criterion)

The capacity of a grated inlet (gully-grating) depends upon its geometry and also upon the flow conditions in the collecting channel. These conditions can be used to define a characteristics length, E, which is termed as the inlet criterion and which is given by the equation:

$$E = 1.010 \times 10^4 \frac{Q}{Y^{3/2}} \qquad \text{(H-4)}$$

Where E and Y are in millimeter and Q is in litres per second; Y is the depth of flow in the channel just upstream of the inlet.

Combining Equation (H-2) and (H-4) gives for channels of triangular cross-section the equation:

$$E = 7.90\ C^{9/6}\ Q^{7/16} \qquad \text{(H-5)}$$

Where C is defined by Equation (H-3).

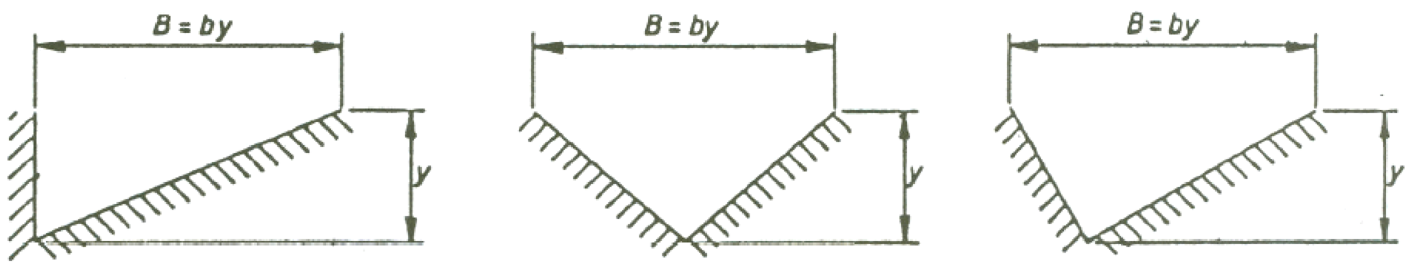


Figure H.1 Channel cross section-definition of effective side-slope b

H.3 Capacity of Kerb-inlets

In order to intercept all the flow in a collecting channel, a kerb-inlet should have a length Li of clear opening given by the equation:

$$L_1 = K_1 E \qquad \text{(H-6)}$$

Where *E* is the value of the inlet criterion given by Equation (H-5). Any struts or bars should be placed so as not to obstruct the flow. K_1 is a factor that varies with the effective cross-final of the collecting channel; the following values of K1 have been determined experimentally:

Values of K1 for 12>b>24 should be interpolated linearly. If the actual length, L, of the inlet is less than L1, then it will only intercept part of the flow in the collecting channel. The blow that by passes the inlet, q, can be expressed as a proportion, p, of the total flow approaching the inlet and if given by the equation:

$$P = 1 - \frac{L}{L_1} \qquad \text{(H-7)}$$

Provided that P is not greater than 0.4.

H.4 Capacity of Grated Inlets

H.4.1 General

Grated inlets should be installed in collecting channels as closed as possible to the kerb. Figure H-2 shows the general case of flow to a rectangular grated inlets set in collecting channel of triangular cross-section. Flow can by-pass an inlet in the following ways:

(a) Between the kerb and the slots of the grating (the carry-by flow, q_1);
(b) Over the grating, by water passing over the bars (the carry-over flow,q_2);
(c) Around the grating, by water flowing around the outside edge of the grating (the carry-past flow, q_3).

H.4.2 Carry-by-flow

The flow between the kerb and the first slot (or slots) of the grating, q1, can be expressed as a proportion, P1, of the total flow approaching the inlet, experiments show that:

$$P1 = \frac{q_1}{Q} = \frac{24}{b^2}\left(\frac{E}{L}\right)\left(\frac{d}{c}\right)\left(\frac{d}{Y}\right)^2 \qquad \text{(H-8)}$$

Where:

d is the width of the gup (inmm) between the kerb and the first slot;

L is the length of the grating (in mm) measured along the kerb (see Figure H-2);

Y is the depth of flow (in mm) in the collecting channel.

The value of P_1 will often be small enough to be neglected when determining the spacing of inlets.

H.4.3 Carry-overflow

The length of grating, L2, required to prevent any flow passing over the bars is related to the inlet criterion, E, by the equation:

$$L_1 = K_2\left(\frac{E}{b}\right) \qquad \text{(H-9)}$$

Where b is the cross-fall of the channel and, k2 is a constant that depends upon the design of the grating. For a grating with bars parallel to the kerb and with transverse bars at quarter points, k_2 = 16. For heavy duty gratings with bars set at 450 to the kerb K2 =24 (see Figure H-2). For a grating with transverse bars a value of K2= 24 can also be taken. If the actual length of the grating, L1, is less than L2, some flow , q2, will pass over the bars. If this flow is expressed as a proportion, P2, of the total flow approaching the inlet, it is found that:

$$P_2 = \frac{q2}{Q} = \left[1 - \left(\frac{L}{L_2}\right)^2\right]^2 \qquad \text{(H-10)}$$

H.4.4 Carry-past flow

The length of grating, L_3, required to prevent flow by passing the grating around its outer edge is given by the equation.

$$L_3 = 2.4\,E\left(\frac{B-W_p}{B}\right)^{1/2} \qquad \text{(H-11)}$$

Where

B is the width of flow (in mm) in the collecting channel upstream if the inlet;

W_p is the distance (in mm) from the kerb to the outer edge of the grating (see Figure H-2)

If the actual length, L, of the grating is less than L_3, some flow, q3, will pass around the inlet. If this flow is expressed as a proportion, P3, of the total flow approaching the inlet, experiments show that:

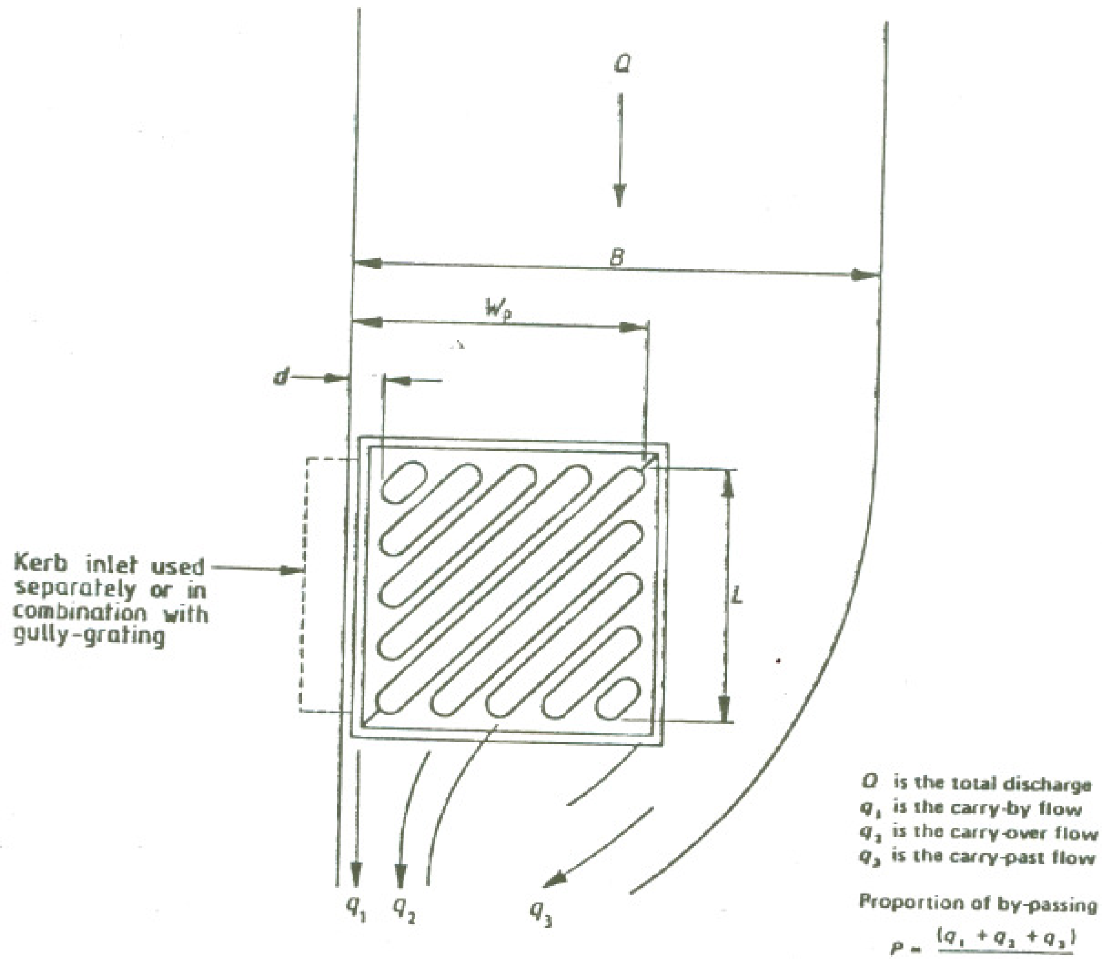
$$P_3 = \frac{q_3}{Q} = 0.60\left(\frac{B-W_p}{B}\right)^2\left(\frac{1-L}{L_3}\right) \qquad \text{(H-12)}$$

H.6 Capacity of combined inlets

A combined inlet consists of a grated inlet and an adjacent kerb inlet having the same length as the grated inlet. This type of inlet is less susceptible to blockage than either the grated inlet or the kerb inlet used separately; but its capacity will normally be only slightly greater than that of the grated inlet.

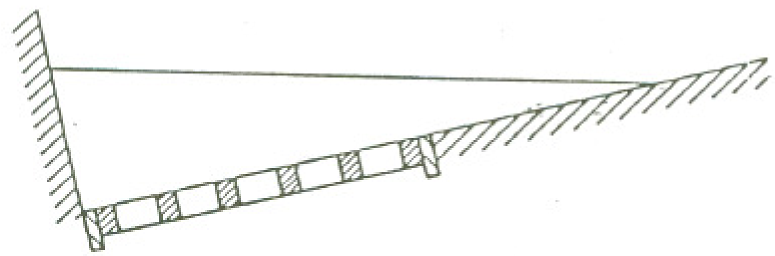
The method of calculating the capacity of a combined inlet is similar to that for a gully-grating (see H.4) apart from the following changes:

(a) *Carry-by flow*: The value of the constant in Equation (H-8) should be change from 24 to 16;
(b) *Carry-overflow*: The appropriate value of the constant K_2 in Equation (H-9) should reduced by 10%.



Q
B
W_p
d
L
Kerb inlet used separately or in combination with gully-grating
q_1
q_2
q_3
Q is the total discharge
q_1 is the carry-by flow
q_2 is the carry-over flow
q_3 is the carry-past flow
Proportion of by-passing
$P = \frac{(q_1 + q_2 + q_3)}{Q}$

(a) Plan



(b) Cross section

Figure H-2 Flow to a rectangular granted inlet

H.7 Capacity Terminal Inlets

Terminal inlets should be located at the down-stream ends of collecting channels and at low points in the paved area. Such inlets should be designed in the same way as grated inlets in roofs.

H.8 Design Procedure for Intermediate Inlets

H.8.1 General

The determination of the spacing of inlets should begin at the upstream end of the system and proceed in the downstream direction. The following factors may affect the spacing of inlets:

(a) Limitations on the maximum width and the maximum depth of flow in the collection channel.
(b) Limitation on the amount of by-passing, if any, to be permitted at each inlet.
(c) The likelihood of blockage of the inlet and the frequency of clearing.

The capacity of an inlet can be increased if some flow is allowed to by-pass the inlet and continue to an inlet further downstream. The increase in capacity can be significant in the case of kerb-inlets, which have a relatively low efficiency in steep channels. The total proportion of flow by-passing an inlet should not normally exceed one-fifth of the flow approaching the inlet.

H.8.2 Limiting the depth or width of flow

The following design data are required: the slop, *s*, and the effective side slope, *b*, of the collecting channel, the relevant dimensions of the inlet *L*, W_p, and (see Figure H-2), the design rainfall intensity, *I*, the flow (if any) by passing the upstream inlet, *q*, the maximum width of flow, *B*, or the maximum depth, *Y*.

The calculate is carried as follows:

(a) Calculate the value of the channel criterion C from Equation (H-3), using the appropriate value of Manning's n from Table H-1.

(b) If the maximum width of flow, B, is specified, calculate the corresponding maximum depth *Y=B/b*.

(c) Determine the discharge, Q, corresponding to the valves of C and Y using Equation (H-2), then calculate the value of the inlet criterion, E, using Equation (H-5).

(d) Calculate the proportion of flow by-passing the inlet.

(e) If the proportion of flow by-passing is acceptable, calculate the area (in m2) that can be drained, Ap, using equation.

$$A_p = 3600 \left(\frac{Q-q}{r}\right) \qquad \text{(H-13)}$$

Where I is in millimeters per hour, the equation assumes that the area Ap is impermeable,

(f) If the proportion of by-passing is excessive, reduce the maximum depth of flow or change the size of the inlet; then repeat steps (a) to (e).

Table H-1 Roughness coefficients for channels

Type of Channel	**Manning roughness coefficient, n**
Smooth concrete Concrete with grit	0.011 0.014

ANNEX I

Design and Construction of Refuse Chutes

1. CHUTES

1.1 Num.ber of Chutes-The number of chutes depends upon the convenience to the user and the quantity of refuse to be handled between two subsequent clearings. Annex J gives the method of calculation of quantity of refuse from residential buildings.

1.2 Individual or Combined System--In continuation to 1.1, if the chute system is designed as individual system, where each flat is served by an independent hopper, it will be to the utmost convenience to the user. However, a common hopper may be provided in each floor for each chute whose number is further decided by the quantity of refuse to be handled.

1.3 Material of Construction - Chutes may be constructed out of asbestos cement or R.c.c. pipe with smooth inside finish.

1.4. Diameter of the Pipe-Chutes shall be of a minimum internal diameter of 38 cm in order to avoid any chokage inside the chute and to enable provision of a choke-free inlet hopper connection.

1.5 Finish - The inside surface of the chute should be finished as smoothly as possible so as not to allow any sticking of refuse particle that may cause choking eventually. .

1.6 Location-The chute may be carried through service shafts meant for carrying drainage pipes. However, the location shall be mostly determined by the position of inlet hopper and the collecting chamber that is most convenient for the user. It should also be considered to locate the chute away from living rooms in order to avoid noise and smell nuisance.

1.7 Construction-The chute pipes should be assembled vertically and properly clamped to the wall. The joints should be of cement mortar and the chute may be squarely embedded into the surrounding walls. A section through a typical chute installation is given in Fig.8.1.

1.8 Ventilation - The upper end' of the chute, that is, beyond the uppermost floor should be provided with a ventilation pipe to the full bore which should rise 2 to 2·5 m above the roof or terrace of the building. An umbrella type cowl with wire mesh at the top will be helpful to prevent rainfall and, other external objects of nuisance potential. For high rise buildings mechanical ventilation of the exhaust type is recommended.

1.9 Chute Maintenance

1.9.1 *Access*-Each chute pipe should be provided with an access door at intervals not greater than every third floor.

1.9.2 *Wrapping of Refuse-To* help preventing spillage and blockage, the residents should be encouraged to wrap their refuse.

1.9.3 *Flushing of Chute-* Y-connection at terrace level may preferably be provided in order to direct a. water hose for cleaning purposes, if needed.

2. **Inlet Hopper**

2.1 Location - In individual chute system, the inlet hopper shall be located in the passage near the kitchen and in the common chute system towards the end of the common passage. Natural ventilation should be adequate to prevent any possible odour nuisance. There should be adequate lighting at this location. For ground floor flats the inlet hoppers may be placed at a higher level and a flight of steps may be provided for using the same.

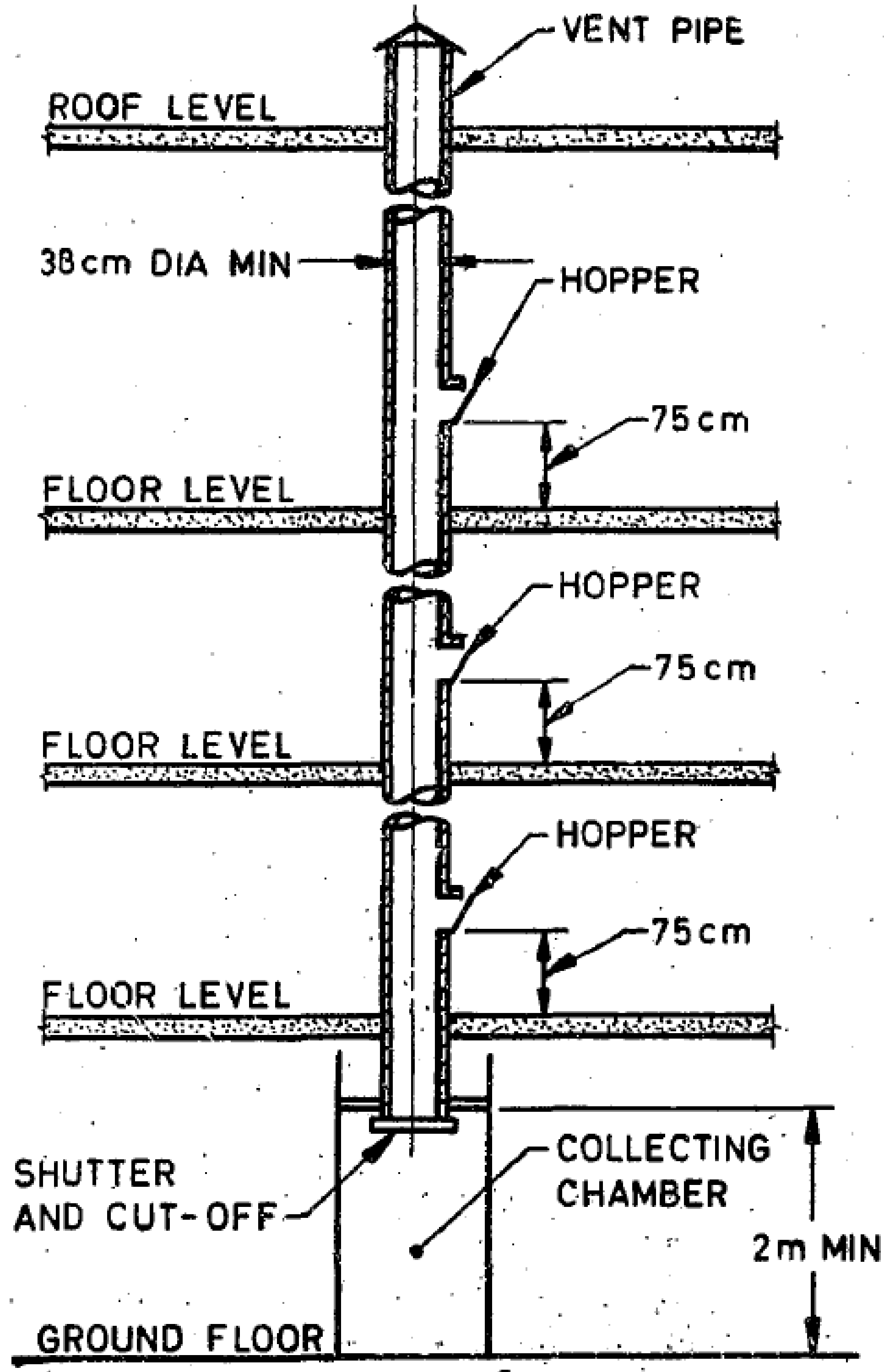


Figure 8.1SectionThrough Typical Refuse Chute Installation

2.2 Design and Construction-Hopper shall be constructed such that there should be mii1imum escape of odour or any other vapour when the hopper door is kept open or closed that the inside portion of the hopper does not lodge any refuse while projecting it into the chute. The door and the frame should be fire-resistant. A typical construction of an inlet hopper is given in Fig. 8.2.

2.2.1 *Size of the Mouth and Throat* - The mouth shall have a maximum size of 25 cm height and 36 cm width. The throat should not be less than the size of the mouth. The diagonal of the mouth should not be larger than the chute size.

2.2.2 *Height of the Hopper-The* hopper should be constructed at a height of 75 cm measured from the floor level to the lower edge of the inlet opening.

2.2.3 *Inner Surface* - The interior of the hopper should slope towards the main chute at an angle not less than 45° to the horizontal preferably 60° for better performance. This portion may be specially built or may be had by providing a suitable· Y-connection. If built specially, the inside finish should be as smooth as possible. If provided by the use of Y-connection, it may be of asbestos cement or cast iron or cement concrete pipe.

2.2.4 *Door, Head, Frame and Receiving Unit* - These should be of mild steel, cast iron or aluminum adequately protected against corrosion. The door should be designed to be self-closing, to have a latch for closing it securely after use and to have a rubber gasket in between the door and the frame for ensuring gas tightness and minimizing noise. The receiving plate should be fitted with two retaining side plates to prevent spillage *(see* Fig. 8.2).

2.2.5 Counterbalance of Door-The door when not in use, should fly back to its closed position and be firmly closed,

2.2.6 Hinge - The hinge shall be such as to satisfy the requirements in 2.2. It should not have sharp edges to harm the user. It should be fitted such that the door' can be taken out for maintenance.

2.2.7 Handle-There should be a handle fixed properly to the door for operating the hopper door.

3. COLLECTION CHAMBER

3.1 Location - The collection chamber shall be situated at ground level.

3.2 Capacity-If the refuse is discharged directly on the floor of the collection chamber, the capacity is designed on the quantity of refuse expected from the chute between two consecutive clearings. It may be recommended to provide a minimum capacity of 0'054m3/family or apartment per day. In the case of chutes serving small number of apartments, the minimum size of the collection chamber shall be 1.2 X 1.2 X 1.8 m in order to facilitate providing trolley and easy cleaning of the chamber. In case of proposals to collect refuse directly into a wheeled receptacle the capacity of the chamber should be sufficient to accommodate as many containers as would be necessary. In that case, a .mild steel container suitably protected against corrosion or a container of any other suitable material may be used. If more than one container, is in use, the minimum clearance of 15 cm between t11e container will be necessary. Normally the height of chute bottom above the top of the container shall be about 30 cm in order not to allow any refuse to spill on: the floor of the chamber. It will be preferable to provide a minimum head room of 2m for the collection chamber to facilitate easy entry *into it.*

3.3 Construction-The walls and roof of the chamber shall be constructed of brick masonry or any non-combustible material. The door should be of steel or any fire resistant material. The door fitting should be properly done with the provision of rebate and reveals *in* the opening so as ,not to allow any gas or fume to escape. The inner surface of the walls, the floor and the ceiling should be plastered with Cement mortar in, order to provide a smooth finish. Preferably the chamber may be lined with glazed tiles for better cleaning and up keeping. The junctions of the walls with each other and with the floor shall be smoothly rounded off to prevent lodging of dust and refuse.

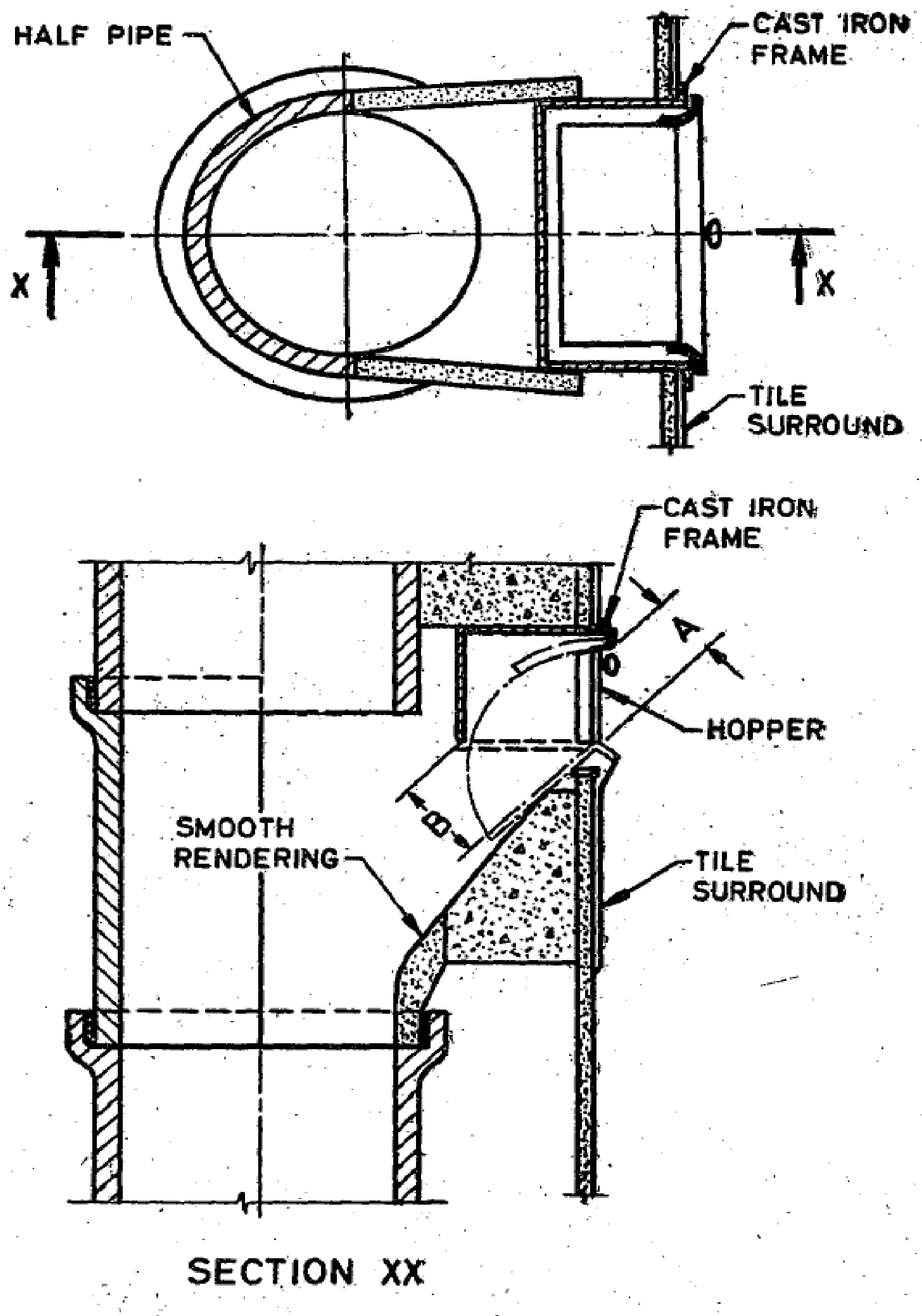


Figure 8.2 Typical Inlet Hopper

3.4 Cleaning and Maintenance-Provision of water tap in the vicinity and drainage facility with a trapped gully shall be made in order to arrange for periodic cleaning of the chamber.
3.5 Shutter-There should be a cut-off plate or shutter at the chute bottom in order to close off the chute at the time of handling refuse in the chamber or while cleaning. The shutter shall be made of sheet iron sliding horizontally inside angle-iron rebates. These should be made non-corrodible with proper painting.
3.6 Lighting- Adequate artificial light should ,be provided in the chamber with its control switch located on the outside wall near entrance.
3.7 Access - There shall be easy access to the chamber for the cleaners and refuse collectors. There should be a well paved pathway leading to the collection chamber from the nearest road in order-to facilitate easy transport of refuse at site,

ANNEX J

Method of Calculation of Total Refuse and Guidelines for Determining Number of Chutes and Size of Collection Chamber

Quantity of domestic refuse
Quantity of refuse = 680 g/capita/day (Assumed average for Addis Ababa)
Density of refuse = 240 kg/m³

Volume of refuse/capita/day = 680/1000 X 1000/240 = 2.83 liters

Assuming that a family residing in a flat would consist of an average of 6 members plus 2 servants, the average volume of refuse per family would be 2.83 X 8 =22.64 liters/day or say 0.027m³/day.

Example:
To consider a multistoried building of20 flats with 2 flats per floor
Refuse/flat: 0.027 rn³/day.

a) No. of Chutes

1. To be decided on convenience to the user; and
2. To be decided on the total number of containers, if used in the collection chamber.

Assuming that individual hopper system will be convenient to the residents, the number of chutes will be two.
To provide for irregularity in municipal refuse cleaning service, collection chamber be designed to accommodate 2 days refuse.

Hence, volume of refuse/clearing = 0.027 m^3 x 20 flats x 2 days
=1.08 m^3
As there are *two chutes, capacity* for each collection chamber will be
1.08/2 = 0.54m³

However, a chamber of size 1·2 x 1.2 x 1.2m will be necessary as a minimum requirement.

b) If containers' are to be used in the collection chamber:

Container size = 0·9 m diameter x 1·3 m high of capacity of 0.826 m³
Volume of refuse/clearing = 0·54 m³
Number of containers/chute = one
The above collection chamber size will be adequate.

ANNEX K

WHO Drinking Water Quality Guideline Values for Chemicals that have Health Significance

Table K-1 Guideline values for naturally occurring chemicals that are of health significance in drinking-water

Chemical	Guideline value[a] (mg/litre)	Remarks
Arsenic	0.01 (P)	
Barium	0.7	
Boron	0.5 (T)	
Chromium	0.05 (P)	For total chromium
Fluoride	1.5	Volume of water consumed and intake from other sources should be considered when setting national standards
Manganese	0.4 (C)	
Molybdenum	0.07	
Selenium	0.01	
Uranium	0.015 (P, T)	Only chemical aspects of uranium addressed

[a] P = provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited; T = provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection, etc.; C = concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, resulting in consumer complaints.

Table K-2 Guideline values for chemicals from industrial sources and human dwellings that are of health significance in drinking water

Inorganics	**Guideline value (mg/litre)**	**Remarks**
Cadmium	0.003	
Cyanide	0.07	
Mercury	0.006	For inorganic mercury
Organics	**Guideline value[a] (µg/litre)**	**Remarks**
Benzene	10[b]	
Carbon tetrachloride	4	
Di(2-ethylhexyl)phthalate	8	
Dichlorobenzene, 1,2-	1000 (C)	
Dichlorobenzene, 1,4-	300 (C)	
Dichloroethane, 1,2-	30[b]	
Dichloroethene, 1,2-	50	
Dichloromethane	20	
Dioxane, 1,4-	50[b]	
Edetic acid (EDTA)	600	Applies to the free acid
Ethylbenzene	300 (C)	
Hexachlorobutadiene	0.6	
Nitrilotriacetic acid (NTA)	200	
Pentachlorophenol	9[b] (P)	
Styrene	20 (C)	
Tetrachloroethene	40	
Toluene	700 (C)	
Trichloroethene	20 (P)	
Xylenes	500 (C)	

[a] P = provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited; C = concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, leading to consumer complaints.

[b] For non-threshold substances, the guideline value is the concentration in drinking-water associated with an upper-bound excess lifetime cancer risk of 10^{-5} (one additional cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). Concentrations associated with estimated upper-bound excess lifetime cancer risks of 10^{-4} and 10^{-6} can be calculated by multiplying and dividing, respectively, the guideline value by 10.

Table K-3 Guideline values for chemicals from agricultural activities that are of health significance in drinking-water

Non-pesticides	Guideline value[a] (mg/litre)	Remarks
Nitrate (as NO_3^-)	50	Short-term exposure
Nitrite (as NO_2^-)	3	Short-term exposure
	0.2 (P)	Long-term exposure
Pesticides used in agriculture	**Guideline value[a] (µg/litre)**	**Remarks**
Alachlor	20[b]	
Aldicarb	10	Applies to aldicarb sulfoxide and aldicarb sulfone
Aldrin and dieldrin	0.03	For combined aldrin plus dieldrin
Atrazine	2	
Carbofuran	7	
Chlordane	0.2	
Chlorotoluron	30	
Cyanazine	0.6	
2,4-D (2,4-dichlorophenoxyacetic acid)	30	Applies to free acid
2,4-DB	90	
1,2-Dibromo-3-chloropropane	1[b]	
1,2-Dibromoethane	0.4[b] (P)	
1,2-Dichloropropane (1,2-DCP)	40 (P)	
1,3-Dichloropropene	20[b]	
Dichlorprop	100	
Dimethoate	6	
Endrin	0.6	
Fenoprop	9	
Isoproturon	9	
Lindane	2	
MCPA	2	
Mecoprop	10	
Methoxychlor	20	
Metolachlor	10	
Molinate	6	
Pendimethalin	20	
Simazine	2	
2,4,5-T	9	
Terbuthylazine	7	
Trifluralin	20	

[a] P = provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited.

[b] For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated with an upper-bound excess lifetime cancer risk of 10^{-5} (one additional cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). Concentrations associated with estimated upper-bound excess lifetime cancer risks of 10^{-4} and 10^{-6} can be calculated by multiplying and dividing, respectively, the guideline value by 10.

Table K-4 Guideline values for chemicals used in water treatment or materials in contact with drinking-water that are of health significance in drinking-water

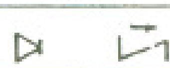
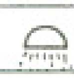
Disinfectants	Guideline value[a] (mg/litre)	Remarks
Chlorine	5 (C)	For effective disinfection, there should be a residual concentration of free chlorine of ≥0.5 mg/litre after at least 30 min contact time at pH <8.0
Monochloramine	3	
Disinfection by-products	**Guideline value[a] (µg/litre)**	**Remarks**
Bromate	10[b] (A, T)	
Bromodichloromethane	60[b]	
Bromoform	100	
Chlorate	700 (D)	
Chlorite	700 (D)	
Chloroform	300	
Cyanogen chloride	70	For cyanide as total cyanogenic compounds
Dibromoacetonitrile	70	
Dibromochloromethane	100	
Dichloroacetate	50[b] (T, D)	
Dichloroacetonitrile	20 (P)	
Monochloroacetate	20	
Trichloroacetate	200	
Trichlorophenol, 2,4,6-	200[b] (C)	
Trihalomethanes		The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
Contaminants from treatment chemicals	**Guideline value[a] (µg/litre)**	**Remarks**
Acrylamide	0.5[b]	
Epichlorohydrin	0.4 (P)	
Contaminants from pipes and fittings	**Guideline value[a] (µg/litre)**	**Remarks**
Antimony	20	
Benzo[*a*]pyrene	0.7[b]	
Copper	2000	Staining of laundry and sanitary ware may occur below guideline value
Lead	10	
Nickel	70	
Vinyl chloride	0.3[b]	

[a] P = provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited; A = provisional guideline value because calculated guideline value is below the practical quantification level; T = provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source control, etc.; D = provisional guideline value because disinfection is likely to result in the guideline value being exceeded; C = concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, causing consumer complaints.

[b] For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated with an upper-bound excess lifetime cancer risk of 10^{-5} (one additional cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). Concentrations associated with estimated upper-bound excess lifetime cancer risks of 10^{-4} and 10^{-6} can be calculated by multiplying and dividing, respectively, the guideline value by 10.

ANNEX L

Symbols

ITEM	OBJECT	SYMBOL
1	Cold water supply pipe	
2	Hot water supply pipe	
3	Recirculation water pipe	
4	Wasted water(over flow,etc)drainage pipe	
5	Fire fighting water supply pipe	
6	Foul water drainage pipe	
7	Vent pipe	
8	Storm water drainage pipe	
9	Sub soil water drainage pipe	
10	Draw - off tap	
11	Float operated valve	
12	Stop valve, service valve	
13	Drain valve (drain cock)	
14	Reducer	
15	Pressure reducing valve (small end denotes high pressure)	
16	Pressure relief valve	
17	Check valve or non return valve	
18	Temprature relief valve	
19	Pump	
20	Water meter	
21	Shower head	

ITEM	OBJECT	SYMBOL
22	Foul water drainage manhole	(F) [F]
23	Storm water drainage manhole (storm water pit)	(R) [R]
24	Subsoil water drainage manhole	(S) [S]
25	Wasted water drainage manhole	(W) [W]
26	Valve protection chamber	(V) [V]
27	Water meter protection chamber	(M) [M]
28	Inlet pit	(I) [I]
29	Floor drain	FD
30	Water heater	(WH)
31	Sink	S
32	Wash basin	WB
33	Bidet	B
34	Water closet	WC
35	Bath tab	BT