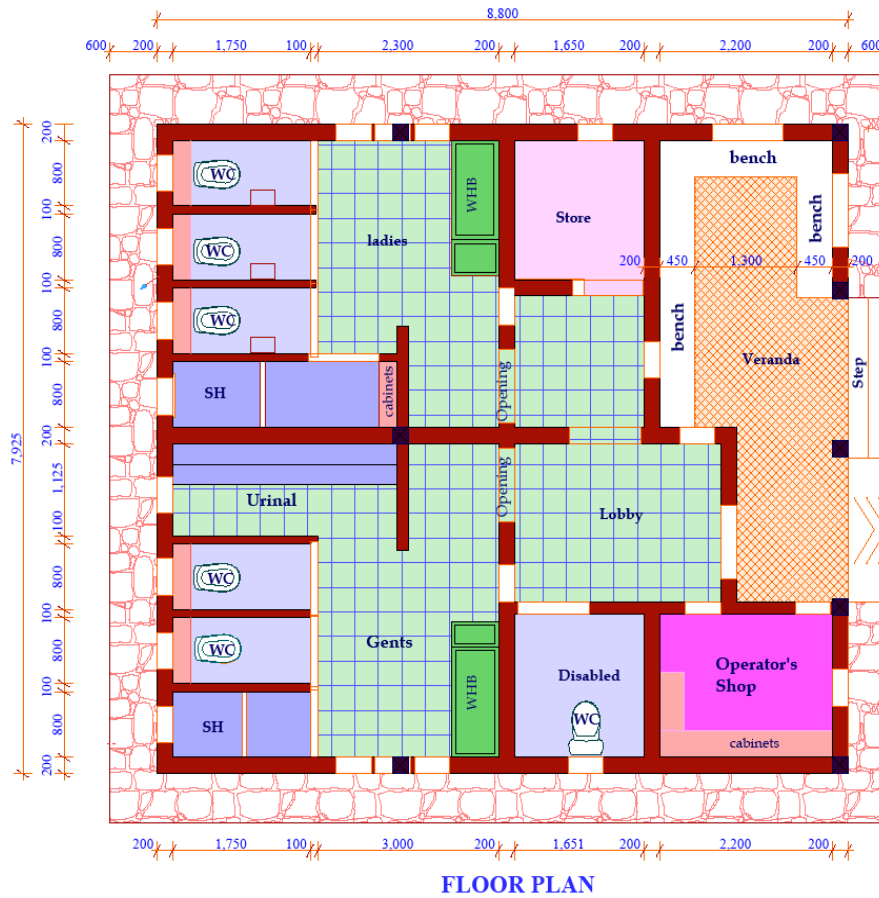


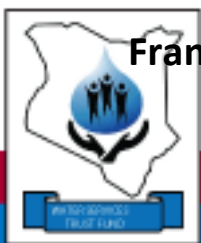
Water Services Trust Fund

Public Sanitation

Construction Supervision Guidelines and Procedures Manual



Drawing of the WSTF Public Sanitation Facility (prepared by Edward Kungu)



Francis Oiro Ochieng

Financial support for improved access to water and sanitation

Water Services Trust Fund [Urban Projects Concept]

Toolkit for Urban Sanitation Projects

Public Sanitation

CONSTRUCTION SUPERVISION GUIDELINES AND PROCEDURES MANUAL

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Toolkit for Urban Sanitation Projects

Public Sanitation

CONSTRUCTION SUPERVISION GUIDELINES AND PROCEDURES MANUAL

1. Introduction

The principle procedures and guidelines for the supervision of construction until the final completion need to be enhanced and adhered to in order to produce a standard end product.

Most of the completed buildings /structures are sub-standard due to improper tendering, evaluation, site investigation, project selection criteria, lack of constant project supervision, unqualified contractors, limited funding of the project which result into purchase of inferior materials, etc.

Safe housing is a fundamental right for everyone. Construction that does not meet public health and building code legislated standards poses serious hazards to health and human life. Some of the easily preventable diseases, such as tuberculosis, meningitis, upper respiratory tract infections and household injuries often occur as a result of unsanitary housing of poor design and construction, e.g. lack of permanent vents (PVs), habitable rooms are too small thus, result into congestion, etc.

Caution in building and maintaining shelters and human settlements is very important. Building explores simple techniques of physical planning, preparation of the ground before construction, prevention of dampness, air, lighting & ventilation and provision of other amenities that ensure human comfort and safety.

2. Physical Planning

The officers and other technicians involved in the construction should visit the site and familiarise themselves with the layout and topography of the area. In particular, they should note accessibility, zoning and any physical features that may promote or hinder safe shelter. A layout should be prepared to show the position of the building access routes, service areas, building line, site and frontage. Before a contractor moves to the site, certain procedures must be followed. You should notify the building inspector, giving all necessary details. The local Authority should be notified and obtain a license as necessary. It may also be necessary to seek permission from the Local Authority for temporary access.

3. Site Investigation

3.1 *Factors to Consider*

It is necessary for both the designer and the builder to know the type of soil formation in the underground the construction is going to take place since the building has to be supported by it. The nature, strength, bearing capacity and likely behaviour of such soils have to be ascertained alongside the loads to be exerted by the building and the wind.

Various factors need to be considered when selecting a site for building purposes. Preliminary factors include smoke fumes, odours and noises. Factors above ground (a) include the presence of the hills, mountains, large trees, buildings and quarries. Underground (b) are subsoil, ground water and service facilities such as electric cables, water pipes and sewer lines. Some other general factors, availability of local materials, information about nature occurrences such as earthquake or cyclones and availability of electricity, water, access roads and other amenities such as hospitals and churches.

3.2 *Why carry out a Site Investigation?*

Why should a site investigation be undertaken?:

- a) To investigate and determine the occurrence or causes of all natural or local changes of conditions.
- b) To enable an adequate, economical and suitable design to be prepared.
- c) To foresee and prevent difficulties that may arise during construction due to either ground or local conditions.
- d) Assess the suitability of the site for the proposed works.

The extent of site investigation depends on the complexity of soil conditions, existing information about the occurrences which may interfere with the stability of the building, foundation arrangements for the structure and the funds availability for the construction. In most cases, site investigation is carried out during the preliminary stages of construction; however, other investigations maybe necessary due to defects or failure of existing work or suspect safety of existing work (the neighbouring buildings).

Investigation is normally done to ascertain the type of soil in relation to the building being put up. Preparing the details of soil samples and procedures are usually the duty of the site engineer.

Such inspection should be done as soon as the excavation work is completed. Not all sites can be suitable for constructing a building. Where such sites cannot be avoided, improvement of the site must be undertaken to make it suitable. E.g. a waterlogged site maybe drained using pipes made of clay, concrete and bamboo or French drains. The pipes are laid into the ground to gradient towards the runoff leading to a watercourse. A long -time solution is to plant fast growing trees such as eucalyptus. Rocky or hilly sites can be improved by clearing and levelling.

If the site has a high water table, then a raft foundation must be used to withstand the water. Waterproof cement should also be used.

3.3 *Setting out a Building*

The setting out of a building is preceded by inspection of the building plan and noting the location lines in relation to other plots. Also, one should establish the building line in relation to the highway or major roads. This is usually done by the site engineer and the Local Authority and is a line which demarcates the outer face of the front building with the major roads. It's a line that no builder should go beyond and ensures that buildings are kept at a reasonable distances from the main roads. The fine details and variations in distances depend with the cities and urban centres / rural areas. At locations where there are many buildings, the building line may be established in relation to the existing buildings on either side of the site.

3.4 *Trenching*

The major preliminary operation for concrete foundation in construction of the walls is excavation of trenches, simply known as "trenching ". This is basically the removal of topsoil to give room for a firm foundation. For deep trenches or areas where several houses are being built simultaneously it may be more economical to utilise mechanical means of trenching. Diggers or excavators such as a dragline, bulldozer, dumper, drag shovel, angle dozer, or skimmer are economical in such situations.

It may be necessary during trenching in certain types of soil to timber the trench. Timbering trenches is mainly done in waterlogged soil or where the soil is so loose that it may collapse. Timbering is necessary to hold up sides of the excavation and avoid them collapsing which might endanger the lives of people working in the trench. Timbering avoids wasteful labour of constantly clearing off falling earth from the trench bottoms. The amount of timbering used in any excavation depends on the following:

- Soil to be supported.
- Depth of trenches.
- Length of time during which the excavation is to remain open.
- Quantity of timbering materials available.
- Movement of heavy vehicles within the site.
- Vibrating machines in use, either for trenching or within the site.
- Heaps of exactions on adjacent ground.

There are three common methods of timbering of trenches: polling, walling and sheeting. Polling is the use of polling boards and struts. It is used on compact and firm soil. Walling is used on moderately loose soil using polling boards, walling and struts. Sheeting is done on loose, waterlogged soil using sheeting, polling boards and struts.

4. Foundations

4.1 *Introduction*

The foundations of a structure from the base that a building rests on; it supports the walls or columns. The soil or rock is referred to as the *natural foundation*, and the bases of the walls or columns form the *artificial foundations*. Artificial foundations

depend on the type of building to be constructed and the nature of the soil. The purpose of foundations is to sustain the building's weight as well as other loads superimposed on it. Foundation receives and spread the load from the structure above it over a safe area of the subsoil, providing a stable level on which to build. This protects the structure from damage due to soil movement caused by shrinkage or swelling.

Various conditions dictate the type of foundations needed. A main concern is the type of building or structure, that is, whether domestic or industrial, single or multi-storey. The nature of soil and site conditions is also important. Other consideration are the weight of the building and any possible effects of weather elements such as rain and winds.

4.2 Bearing Capacity of the Soil and Settlement of the Building

4.2.1 Bearing Capacity of the Soil

The principle of how the artificial and natural foundations take care of the load of a building depends on the bearing capacity of the soil. This is the maximum load per unit area [tonnes per square metre] which the ground can support without displacement. This depends on loading capacity. Therefore, it is necessary to determine the nature of soil in relation to expected dead load or weight. The nature of soil varies from place to place. Variations may even occur on the same building site. It is important the correct foundations be determined for a given building.

The ultimate bearing capacity is the maximum stress a structure can take at a failure that is the list pressure which would cause a shear failure of the supporting soil immediately below or adjacent to the foundations. In other words, it is the intensity of loading at which failure occurs. The safe bearing capacity of the soil is the ultimate stress the soil can bear safely before giving way.¹

$$\underline{\text{SAFE BEARING CAPACITY} = \text{ULTIMATE BEARING CAPACITY} / \text{FACTOR OF SAFETY}}$$

4.2.2 Settlement of the Buildings

The bearing capacity and the ultimate bearing capacity play a significant role in settlement of a building. Settlement of a building is the vertical downward movement of the base of a structure. Their effect on the structure depends on the magnitude, uniformity, time, nature of the soil and the structure itself. A settlement of a building is normally evidenced by cracks or sifs of a part of the structure (building).

The causes of settlement include the imposed weight of a structure on the subsoil. Changes in moisture content of the soil (e. g frost action) subsidence due to mining, or similar operations, shrinkable subsoil, movement of the ground water, general earth movement, slipping of the strata on slopping sites and excessive vibrations. All these may create movement in the natural foundation with corresponding movement of structure on it.

¹ The calculation is always done by the site Engineer and other relevant officers [technicians].

There are two types of settlement: equal [or uniform] settlement and unequal settlement. Equal settlement is the process by which a building settles on the foundation uniformly and achieves maximum stability or balance. Equal settlement may occur with uniform or minimum cracks in the structure. With unequal settlement a building displaces subsoil in a uniform manner, thus destabilising the building and creating differential resting positions. The effect of unequal settlement may be evidenced by cracks on walls, distortion of the doors and window openings and walls thrown out of the vertical and collapse of buildings.

4.3 Types of Foundations

4.3.1 Introduction

There are seven common types of artificial foundations:

1. Common strip foundations.
2. Deep strip foundations.
3. Wide strip foundations.
4. Stepped strip foundations.
5. Pad foundations.
6. Raft foundations.
7. Pile and beam foundations.

4.3.2 Common Strip Foundations

Strip foundations are the commonest type. They are used for one – or two-storey houses or for buildings up to four storey's they must be constructed on firm non – sinking subsoil. Strip foundations consist of a continuous strip of concrete which bears the load of the building.

4.3.3 Deep strip Foundations

Deep strip is used when the depths of more than 900 mm have to be reached in clay or marshy soils. The trench is normally narrower than that of strip foundations.

4.3.4 Wide Strip[Foundations

This is used where the soils have low bearing capacity such as marsh, soft clay and build up soils. The concrete is reinforced in both transverse and longitudinal directions.

4.3.5 Stepped Strip Foundations

Usually used on a sloping site. Laps should not be less than the thickness of the concrete slab and not less than 300 mm. The steps should be constructed in multiple walling units, e.g. concrete blocks or stones.

4.3.6 Pad Foundations

Pad foundations are generally isolated, consisting of a block of reinforced concrete meant to support reinforced concrete or steel, especially in framed buildings. The thickness should not be less than 150 mm.

4.3.7 Raft Foundations

Raft foundations cover the entire area of the building and may extend beyond it. They consist of sustainably reinforced concrete up to 300 mm thick.

4.3.8 Pile and Beam Foundations

Pile and beam are alternatives to deep strip foundations. They are necessary where a building is constructed on clay, marshy, or soft soil. The pile enables the weight of the building to be carried by firm ground below the poor topsoil.

(See also Figures 11.3 - 11.9 of the Appendix).²

5. Floors

5.1 Floor Construction

The floor is a level surface of a building on which everything rests; the floor supports all the live and dead loads. Floors are classified based on materials and location. Generally, floors are made up concrete, timber or bricks. They may be solid, raised, suspended, basement or upper floors. A building must have a ground floor. The ground floor prevents dampness from entering the building by providing a damp-proof membrane. It also prevents the growth of vegetable matter and other living organisms inside the building. The floor must be provided with an acceptable surface finish for comfort, safety, and heat retention. It should be reasonably strong and stable so as to require minimum maintenance or replacement work. It should further support without failure the loads imposed on it by the people and furniture in the domestic houses, or wares and machinery in warehouses and factories.

A solid ground floor is relatively cheap particularly on a level site. It does not require under floor ventilation but can make use of a wide selection of floor finishes. The quantity of materials required is less that for a suspended floor.

A solid floor includes the essential subfloor (normally referred to as the base course or floor base) and floor covering. The subfloor comprises hard core, blinding, over site concrete and damp-proof membrane. The subfloor supports the floor covering, provides damp resistance and insulates.

The upper floors of a building must be reasonably durable, sustain their own weight and sustain weights of the walls, roofs, people and furnishings. The there are many occupants or large combustible items. It should minimise noise transfer from upper floors to lower floors and provide an acceptable surface finish which is safe, comfortable and attractive.

² The numbering of the figures referred to in this document originates from the documents they were copied from (see List of Literature Used).

5.2 Floor Finishes

The type of floor finish depends largely on the use of the floor. For garages, stores, workshops, and sheds, a top over side concrete may suffice, but for domestic and public buildings different floor finishes may be instituted as desired. These may include cement sand screed, red oxide paint, tiles, timber, granolithic paving (cement, granite), magnetite joint less (anhydrite, calcium sulphate with water). Different floor finishes may be used in different rooms of a house, e.g., kitchen, bathroom or lounge. Floors of domestic and public buildings should be durable to avoid excessive maintenance and replacement costs; they should resist wear from heavy human traffic, furniture and equipment. Floors should be quiet when walked on. In certain buildings such as hospitals and libraries a noisy floor is quite irritating to the users. There should be resistance to water and chemicals, especially in kitchens, bathrooms and laboratories. A good floor should resist fire from many sources; including cigarette stubs which are carelessly discarded floor finish should be non-slippery to avoid accidents, especially in bathrooms and kitchens. Attractive appearance is a factor in the choice of floor finish, especially for living rooms, office and commercial studios.

6. Walls

6.1 Wall Construction

Walls are major components part of a building. Walls enclose and protect a building from extreme weather and offer privacy and security to occupants and their belongings. Walls are classified as load-bearing walls or non-load-bearing walls. Load-bearing walls carry vertically imposed loads such as beams or roofs in addition to their self load. Non-load-bearing walls support no other load except their own weight. These include walls under windows, dwarf walls or partition walls.

Walls should be able to support upper floors and roofs together with all loads imposed on them. They should resist dampness and provide adequate thermal insulation which prevents excessive heat loss from within the building, large heat gain from outside in hot weather and expansion and contraction of the structure. Walls should also provide sufficient solid insulation. Walls should not be stiff since stiffness promotes vibration and reduces sound insulating quality. Walls should also offer fire resistance in a building by inhibiting the spread of flames and preventing the transfer of excessive heat from one side to the other. During fire, a wall should not disintegrate but continue to bear its load, enclosing space as long as necessary in order to preserve the building, its occupants and their belongings (See also Figure 11.10 of the Appendix).

6.2 Common Walling Materials

6.2.1 Brick Work

Brickwork may be burnt bricks or sun-dried bricks. Burnt bricks are durable, waterproof and attractive. Bricks can only be found in certain parts of countries. Brickwork needs a good bricklayer to do job satisfactorily. During construction, bricks are arranged in course so that individual units are tied together and vertical joints of

the successive courses do not lie in the same vertical line. This is called *bonding*. Brick bonding is the interplacements of bricks formed when they project beyond those immediately below and above them. There are four types of brick bonds:

- Stretcher-used on half-brick-thick walls; all bricks are laid as stretchers on every course.
- Header- used on one-brick-thick walls; every brick shows a header face on each side of the wall.
- Flemish- has alternate header and stretcher faces in every course; is attractive and reasonably strong.
- English- has alternate courses of headers and stretchers; provides a very strong bond.

Brick bonding increases stability and strength by distributing the load weight evenly over the whole length of the wall. It also gives a pattern to the face of the wall. Brick walling is relatively cheap, fire resistant, etc. It will not deteriorate structurally and therefore requires less maintenance over a long period of time. Delivery of bricks to site often poses problems of breakage, however. Damage occurs and surfaces are chipped. Due to the small size of bricks, construction takes longer than when using blocks or dressed stones.

Stone is one of the oldest wall materials known to humans.

The art of building with stone masonry.

When stone masonry is used it is either rubble walling or ashlar walling. Rubble walling uses random rubble, undressed stones, squared rubble or stones with roughly straightened edges. Very little or no dressing is used on the stones. Ashlar walling uses well-dressed with sharp, straight edges and smooth faces (See also Figure 11.11 of the Appendix).

6.2.2 Blocks

Blocks made of cement, sand and water are widely used in many countries. The ratio of cement to sand depends on the quality of block needed, but usually 1:3 or 1:4 cement: sand is preferred. Blocks may be made of different sizes. Generally they are 450 mm long, 225 mm high and 150 mm thick. Stretcher coursing as in brick work is applicable.

6.2.3 Concrete

Concrete walls are made of a mixture of cement, sand, ballast and water. Sizes can be small or the same as cement blocks. Sometimes the walls may be created on site, or they can be transported to site. Concrete walls may need pillars and columns for stability.

6.2.4 Timber Work

Timber work constitutes a temporary structure in most cases, but plywood is widely used for partitioning in both domestic and office buildings. Timber also serves as in-fill panels for framed structures. Though comparatively cheap, timber may need to be treated properly with wood preservative to prevent damage from fungi, insects and moisture. Timber is vulnerable to fire.

6.2.5 Metal Sheets

Metal sheets are used for temporary buildings. They are suitable for construction of sheds, stores and buildings site offices. The structure is easy to erect but it remains relatively hot or cold days, respectively. The metal sheets are nailed or screwed on vertical iron or timber frame.

6.2.6 Mud and Wattle

Mud wattle is typical mud houses. The walls are woven with sticks, bamboo or reeds. Mud is then inserted between to cover all spaces. Mud is also used to smooth finish the walls.

6.2.7 Bamboo or Reeds

Bamboo or reeds may be used in temporary but also in permanent structures, such as chicken houses or...prefabricated water kiosks.

7. Dampness

7.1 Introduction

Dampness is the presence of moisture or water content on the surface of inner walls or other inner finishes. Moisture accesses the building and makes it wet and damp. Dampness comes in many forms: rising, penetrating and soaking.

7.2 Rising Dampness

Rising dampness is the upward vertical movement of moisture arising from the ground either through hard-core or walling material brought about by capillary attraction. This type of dampness is caused by lack of horizontal damp proof course (DPC) and damp proof membrane (DPM), high water table (especially if DPC and DPM are not provided or placement of soil or sand beyond or above the horizontal DPC in the outer part of the building).

Rising dampness can be prevented by:

- Providing a DPC or DPM.
 - Draining of waterlogged site.
 - Constructing raft foundations in waterlogged sites.
 - Avoiding heaping of soil above the DPC level.
 - Avoiding planting trees in close proximity to buildings.
- (See also Figure 11.12 of the Appendix).

7.3 Penetrating Dampness

Penetrating dampness occurs as result of rainwater falling against the outer surface of the wall and finding its way into the internal surfaces. This dampness is caused by porous walling materials, poorly finished joints or short eaves. Penetrating dampness can be prevented by use of:

- Non-porous building material.

- Appropriate wall finishing, i.e., effective jointing.
- Long eaves.
- Cavity walls.
- Rough casting on external wall surfaces.
- Proper plastering of both the external and internal surfaces to a smooth finish.

7.4 Soaking Dampness

Soaking dampness occurs as a result of downward movement of water which finds its way into the internal surfaces of a building. Leaking roofs and roof water tanks, pipes, poorly protected parapet walls and poor flushing of chimneys can cause soaking dampness. This kind of dampness can be prevented by providing properly weathered coping stone and DPC on all parapet walls.

8. Roofs

The roof is a framework of timber, steel or concrete on which a covering of thatch, corrugated iron sheet, asbestos, asphalt or tiles is placed. Roof components are rafters, purling, wall plate and tie-beams.

The broad classification includes pitched, flat and trussed rafter roofs. Roofs of more than 10 degrees slope are considered to be pitched roofs. These are further divided into single roofs and double or purling roof. Single roofs consist of rafters supported at the ridge and wall plate. Single roofs include the following: lean-to roof for spans of up to 2.5m, couple roof for spans up to 3m, close couple for spans up to 4m or collar roof for spans up to 5m. A double roof may be a double lean-to, butterfly or strutted purl in roof.

Flat roofs have less than 10 degrees pitch. With adequate falls and good design, flat roofs may be considered the only practical form for many large buildings and those of complicated shapes. When spans exceed 5m, it is considered uneconomical to use rafters alone since the sizes of the timbers will need to be greatly increased. To escape from this obvious waste, a double lean-to or purling roof is used. The purl in divides the rafter span into equal lengths so that the rafters can be economically sized. The purling are supported by struts which are jointed to load –bearing tie beams. When the span to be covered by the roof exceeds 7.5m, it may become necessary to fasten roof components together. This is known as *trussing* (See also Figure 11.13 and 11.14 of the Appendix).

9. Stairs

Stairs are devices for accessing upper floors. Stairs should have a minimum width of 1m. They should be constructed with timber, metal or concrete bolus-trades for safety. For domestic use, the steps should be between 210mm and 220mm with a rise of between 175mm and 220mm. The maximum number of steps in a flight is preferably 12 and should not be more than 15. Enclosed stairs with either a balustrade or wall is called a *staircase* (See also Figure 11.15 of the Appendix).

10. Ventilation

10.1 Air Ventilation

Air must be adequate in quantity and quality for good health. To maintain sufficient pure air indoors, adequate natural and artificial ventilation must be provided. Acts, laws or building codes require that any house fit for human habitation must be provided with adequate means of ventilation apertures should not be less than 20 per cent (%) of the total floor area.

There are many reasons for ventilating buildings. One reason is to provide oxygen and prevent high concentrations of carbon dioxide. Constant air movement in and out of the building helps to regulate and maintain heat balance. Ventilation helps to prevent the concentration of bacteria-carrying particles; it also removes body odors and products of combustion, e.g., smoke from a fireplace. Ventilation helps to meet occupants' respiratory or body requirements.

10.2 Natural Ventilation

Natural ventilation constitutes the ventilation openings which are the actual open able parts of windows or any hinged panels, adjustable louvers or other ventilation, overhanging eaves and perforated walls provide satisfactory microclimatic conditions within a room, but if found insufficient, these should be augmented with roof ventilation.

10.3 Artificial Ventilation

Artificial ventilation is mechanical ventilation adapted to any conditions. It may include an extraction system (known also as a vacuum system), an input system (known also as a propulsion system) or balance system consisting of a combination of both extraction and input systems.

Air conditioning refers to the technique in which air is filtered, washed, dried or humidified and then warmed or cooled and distributed.

If the amount of cubic space in a room is equal to 600 cubic feet per person, then the air in the room is considered to be changed at least once per hour. Therefore, it is recommended that in living rooms and bedrooms each person should be supplied with at least 17 cubic meter of fresh air per hour. The amount of fresh air delivered into a room may be calculated thus:

$$Q=AV$$

- Where Q = Quantity of air delivered per hour.
- A = Total area of inlet in square meters.
- V = Velocity of air in meters per hour.

Procedures for investigating efficiency of ventilation include the following:

1. Enter the room from the open air and note the impression of the room.
2. Note the cubic capacity, ignoring the height above 4 metres.
3. Note the number of windows and the extent of opening.
4. Note any fires or gas burners.

5. Accurately calculate the amount of air entering the room.
6. Take wet and dry bulb hydrometer readings to determine the relative humidity.
7. Note the number of occupants.
8. Take a kata thermometer reading to determine the cooling power of air as affected by the rate of air changes. Compare readings from both inside and outside the room.
9. Take globe thermometer reading to determine the radiant heat exchange.
10. Take an air sample to determine the carbon dioxide content.

Occupied rooms must have regular air change to avoid discomfort for the occupants. Contaminated air could produce headache, sweating or giddiness. It has been proved that such discomfort is due to the physical property of air and occurs as a result of retardation of the normal process of heat loss from the human body.

11. Lighting

11.1 Introduction

Natural lighting is an essential component of the design of a building. Good quality light in a building depends on contrast, that is, the variation between light and dark, without glare. Good quality lighting helps occupants see and recognise objects with the minimum of eyestrain; the better the light, the easier the work. Although quality varies according to the user, light must be agreeable and without sharp shadows which can cause eye fatigue. Building codes require that any house fit for human habitation room and working area, including the kitchen.

Lighting is important in human habitats because it provides visibility and protects good eyesight and eyes from strain. Good lighting may prevent accidents and assist in cleanliness. Work output in any undertaking is increased and economical gain is realised since workers can be precise and in good health.

11.2 Daylight

Daylight is visible radiant energy from the sun and is measured in lumens. The base unit of luminous intensity is known as a candela (cd), a lumen being a unit of luminous flux emitted by a candela within a solid angle of one steradian; and flux being the unit of illumination equal to one lumen per square metre (m²). The old “rule of thumb” requirement that window area must not be less than one-tenth the floor area is now obsolete, and instead the window area is now adjusted to the purpose of the room. It is intended to serve the position of the window in relation to the available skylight. Therefore, the natural lighting of a room depends not only on the window size and shape but on orientation, adequacy of daylight, obstruction (angles of light) and decoration.

Maximum daylight is obtained in a room when the largest possible area of the floor and walls receives light directly from the sky. Therefore, the extent to which a room is lighted directly depends on the skyline available, that is, the amount of floor and wall surface in the room depends largely on aperture, that is, the actual amount of sky visible from that point.

In built-up, populous areas, buildings often obstruct sunshine from each other. The amount of obstruction depends on the height and distance between buildings and varies with the time of the year.

Daylight illumination at any point in a room is expressed as a percentage of illumination at a given point on a plane outdoors and in a position exposed to an unobstructed hemisphere of sky. The daylight factor can be calculated using the following equation:

$$DF \cdot E^0 = E^1 \cdot 100$$

Where E^1 = I luminance at a point inside.

Where E^0 = I luminance prevailing outside.

11.3 Artificial Lighting

The sources of artificial light generally in use in Africa are firewood, kerosene, gas and electricity. Lamps are broadly of two types: Incandescent and discharge. Incandescent lamps contain a filament of tungsten wire which when heated to 2,690 degrees by passage of a current through it gives off heat and eventually light. Some public health laws require that any house fit for human habitation means in each room, staircase, passage and cellar in use. Discharge lamps are usually in the form of tubes contain a gas and sealed at each end with an electrode. Current passes from one electrode to the other through the gas conductor. The gases in general use are sodium with neon or mercury vapor with argon.

12. Security and Safety

12.1 Introduction

A building must be safe and secure for the user. In this regard, a building must conform to regulations in public health acts and building codes. The person responsible for any building should ensure that safety precautions are taken. They should have regard for structural conditions in the building and for the number of people living there. Safeguards may be provided against the danger of accidents. Depending on the use and needs of a building, the following points need to be observed carefully.

12.2 Fence and Boundary Wall

Any developer must provide boundary walls, screen walls, fence or other means of enclosure of approved material for the plot.

12.3 Means of Escape in Case of Fire

Any domestic or public building which exceeds two storey's in height and in which the floor of any upper storey is more than 6m above the surface of the street or ground on any side of the building must be provided with means of escape. All buildings of warehouse class or any addition to such building must have reasonable means of

escape. Every fire escape from an upper storey must terminate at ground level and at a point where the dispersal into a safe area can be quickly accomplished.

12.4 Non-slip Surfaces and Edges

All gangways and exit ways and the treads of steps and stairways must be maintained with non-slip surfaces. Edges of the treads of steps and stairways must be conspicuous.

12.5 Width of an Exit

The width of an exit must not be less than 85 per cent (%) of the width of the corridor or passage leading to it. Stairs for public use should be constructed without windows.

13. Doors

13.1 Introduction

The doors should be hung in to open in the direction of the exit; they should be hung so as not to obstruct, when open, any passage, gangway, staircase or landing. If doors are also used as entrances, one fold must open both ways.

13.2 Chains and Padlocks

If chains and padlocks are used for securing exit doors when the public have not in premises, a keyboard should be provided in an approved position and before the admission of the public. Chains and padlocks should be hung on the board, each in an allotted position and should remain therefore the whole time that the public are in the premises.

14. Drainage

14.1 Introduction

The function of a satisfactory system of drainage is to convey all faecal matter and waste liquid from a building or premises into a sewer or other means of sewage disposal, as quickly as possible, without danger to health. For drainage to be effective and serve the intended purpose, it must meet various criteria. Pipes must be strong, impervious, and non-corrosive and of good quality; all joints must be watertight. The gradient of all drains should provide a self-cleaning velocity. All parts of the drain must be accessible, and all sections between points of access should be effectively trapped, with the exception of ventilation pipes. No drains should pass under buildings unless unavoidable. A house drainage system must be completely disconnected from the public sewer by means of a disconnecting or intercepting trap. This is unless the local authority permits the omission of the same. All drain accesses should be on the exterior of the building and branch drains should be kept as short as possible. Junctions should be made following the direction of flow. Drains must not

be laid in close proximity to trees because of possible damage by roots. Every part of the drainage system must be adequately supported.

14.2 Plumbing systems

A plumbing system involves the laying of pipes which are used to carry liquids such as water or sewage to an intended destination. A drain is channel, conduit or pipe carrying liquid such as water or sewage from a building or yards to an intended destination. A sewer receives drainage from two or more buildings.

There are two main systems of plumbing commonly used: combined and separate. The combined systems of drainage involves the principle that waste pipes from baths, sinks, urinals and water closets are carried into one main vertical soil pipe. By this arrangement all waste from fittings is connected to a vertical pipe conveying excreta. It is vital that the system is adequately ventilated and has traps with a special seal of not less than 75mm in depth. In a separate two-pipe system, waste water and soil water are drained separately to ground level. When this is done, a gully trap must be provided before the waste water drain is connected to the soil water drain at ground level. If the waste water is to be treated or disposed of separately from soil water, the trap is not necessary.

This topic discusses the water carriage system used to remove human waste from the premises to the disposal point. Waste, in this topic, includes domestic, industrial and natural waste. Human waste includes soil waste and waste water.

14.3 Drain Pipe Materials

There are many different types of drains. The commonest ones are made of cast iron, polyvinyl chloride (PVC), pitch fibred, asbestos cement, stoneware concrete or clay. In addition, waste water may also be discharged through lead, copper, aluminum, wrought iron or steel pipes.

14.3.1 Cast Iron

Cast iron is manufactured from iron ore. It is a heavy and rigid material that can withstand very high compression {crushing} pressure, but it cannot be bent; it cannot withstand high tensile force. Iron pipes {especially cast iron and wrought iron} corrode and rust very fast. They therefore require protection from galvanising or immersion. Galvanising is dipping the iron into zinc that forms a protective coating. The zinc oxidises instantly and so forms a coating on the surface. Immersion in a solution of coal, tar, resin and linseed oil makes galvanised material even more protected. Another treatment involves heating the cast iron and then submerging it in superheated steam for one hour. This results in a formation of a thin layer of black magnetic oxide which resists corrosion.

Cast iron pipes are normally 2 or 3 metres long. They may be provided with sockets and spigots to facilitate jointing, or they may be plain on both ends. They are best used near the surface of a road with heavy traffic, in unstable ground where earth movement is likely to occur, under a building or above the ground (See also Figure 12.1 of the Appendix).

14.3.2 Stoneware

Stoneware is made from the mixture of sand, cement and flint (small hard stones), thoroughly mixed and cast on to casting moulds. The pipe is then burnt. It is normally made of short lengths of about 0.5 to 1m. It is a very heavy material that can withstand a fairly high compression force, but is very brittle and cannot withstand any vibration or movement. The material is corrodible and may need to be protected by salt which is introduced during burning; it combines with aluminium and silica to form a shiny protective coating. Stoneware can easily be interchanged with cast iron but may require further protection (See also Figure 12. 2 of the Appendix).

14.3.3 Pitch Fibre

Pitch fibred pipe is made from wood cellulose. Pitch fibred is a very strong material that can withstand a high tensile force and so can be used in unstable situations. It is resistant to acid attack and is usually made into long pieces of between 1.7m and 3m. For jointing purposes, most pipes are provided with a socket and spigot where respective internal and external sections are tapered to facilitate easy jointing. Some pipes may be made without the socket and spigot. In this case, a pitch fibred coupling is used for jointing.

14.3.4 Polyvinyl Chloride

Plastic is used in almost all pipe work: for water supply, waste drains and sewerage, electrical and telephone tubing and gas. PVC pipes are light and flexible, but they are liable to deteriorate with heat as they become progressively hard and brittle on continuous exposure. They are therefore unsuitable for work above ground. PVC pipes are provided with a socket at one end and spigot at the other to facilitate jointing which is done by solvent cement that produces a water light joint. The melting point is very low; heating softens the material which can then be moulded into any shape. A new socket can be easily made on the pipe by this means. Pipes are normally provided in lengths of 3 to 6 metres.

14.3.5 Concrete

Concrete pipes are used where large- diameter pipes are required, especially for the discharge of storm water or trunk sewerage, since they are very cheap compared to all other pipes. Concrete pipes are made of the ordinary concrete mix of cement, sand, and ballast at a ratio of 1:2:3. The mixture is cast into the pipes that can withstand a fairly high compression pressure, but they cannot withstand vibrations. They are very convenient for above ground works but require adequate support on shaky sections. Lengths range between 0.5 and 3.0 metres.

14.3.6 Asbestos Cement

Cement and asbestos fibre can be mixed into slurry which is then rolled and compressed into a firm sheet approximately 0.25 mm thick. Pipes are made by laying layer upon layer on revolving steel core. Diameters range from 50 to 450 mm. They

are easy to handle and more economical than cast iron due to their light weight. However, they are brittle and cannot withstand high tensile force.³

14.3.7 Clay

Clay pipes may be made from various clays, both natural and artificial. Natural clay soil is mixed with minimal water, molded into the required pipe diameter and then burnt to make the material strong and durable. To reduce permeability, 0.5 to 1 m. They are normally provided without sockets. They are best suited for open storm water and waste water drains. They are also suitable for draining waterlogged soils.

14.4 Jointing of Drain Pipes

Proper jointing of pipes is essential for the system to run efficiently. Jointing depends on pipe material and type of pipe, i.e., whether it is socket, plain-ended or threaded. Other considerations are where the pipe is laid – on firm ground, loose soil, above ground or through a marshy area- and whether the pipe is old or new. The joint must be watertight to prevent both infiltration and exfiltration of water.

Pipe joints can be metal or non-metal. Cast iron sockets are made of molten lead and spun yarn. Cast iron flanged joints (also known as flexible joints) are also used. Steel pipes are normally threaded where each pipe is fixed on to the other.

Except for PVC and pitch fibred pipes, all others use cement mortar and tarred gasket(yarn) fixed between the socket and the spigot. Pitch fibred pipes are either fixed on to each other or fixed together by a pitch fibred together by a pitch fibred coupling. Where the pipe is to be made connected to another pipe, a pitch fibred adaptor is used. PVC pipes use solvent cement to fix the spigot into the socket. Where the pipe is to be connected to another type of pipe, a valve socket is used. Lead pipes are soldered on to each other. Copper and lead require metal sleeves to strengthen the joints.

14.5 Size and gradient of drains

14.5.1 Size of Drains

Designing drainage pipes is a complicated exercise and should always consider the number of persons using the drainage system and the average water consumption per person per day. Other considerations are the type and number of sanitary fitments, quantity and period of peak discharge and type of drain pipes being used. Domestic sewage flows are highly variable throughout the day. Just as in the case of water usage, two distinct peaks can be observed on a hydrograph. The primary peak takes place in the morning and the secondary peak in the evening. Infiltration of the surface water or storm runoff tends to increase the total daily volume but does not alter the twin peak character of flows. When infiltration and exfiltration do not occur in the sewer, the amount of sewage flow has been shown to be almost equal to the water used. It has

³ **Asbestos has to be handled with the utmost care!** Very fine asbestos dust particles that can fill the air and can be inhaled when working with asbestos (e.g. cutting pipes) are highly carcinogenic (causing cancer).

been established that 60 to 70 percent (%) of total water supplied becomes waste water.

14.5.2 Gradient of Drains

The gradient of all drains should be such that it provides a self-cleaning velocity of approximately 1 m per second. This allows both solids and liquids to drain away leaving away the interior of the drain in a clean condition. To attain this velocity, the following guidelines are given:

- For a 100-mm diameter pipe, the fall to be 1:40.
- For a 150-mm diameter pipe, the fall to be 1:60.
- For a 225-mm diameter pipe, the fall to be 1:90.

The self-cleaning velocity is very important because a very slow speed facilitates deposition of solids, while very high speeds tend to leave behind solids which cause blockages.

14.6 Drain Protection

Drains should be protected when they are laid on unstable ground, through a building or through marshy ground. For long-lasting drain joints, pipes should be laid on firm soils such as murrum. Where soil is unstable, concrete foundations of a 1:3:6 mixes will be necessary. When a non-metal drain is to be laid on unstable ground, a continuous bed of concrete not less than 150 mm thick will be required.

For a cast iron drain on unstable ground, concrete piers behind every joint are necessary. The piers should be a minimum 300 mm square, of 1:3:6 mixes and resting on a 500-mm square concrete base. The pipe should rest on a cast iron plate on every pier, fixed by means of a U- trap.

If a drain has to pass under or through a building, it must be made of cast iron which can withstand the weight above it. Any other material should be embedded in a concrete mix of 1:3:6 with a minimum of 150 mm thickness. If passing through a masonry wall, it should further be protected by a lintel (See also Figures 12.3 - 12.6 of the Appendix).

14.7 Drain Access

One of the main requirements of good drainage is that the entire drainage system must be accessible for the purpose of inspection, testing and clearing in case of blockage. A public health act states that access to all parts of the drainage system must be provided where there is a junction of two or more drains; a change of direction (both vertically and horizontally), gradient, size, diameter or levels; a straight line of more than 20 m. Access to the drains may be in the form of an inspection chamber or manhole for drains below ground or an inspection eye for drains above ground (See also Figures 12.7 and 12.8 of the Appendix).

14.8 Inspection Chamber

An inspection chamber is provided with an iron cover at ground level. Such chambers are usually constructed over drains where several branches meet. The chamber facilitates examination, cleaning and immediate access for removal of any obstruction in the drain. Inspection chambers should be provided at any change of direction and at intercepting traps. The foundation of an inspection chamber should be a minimum 125 mm thick and of 1:3:6 concrete mixes.

Both depth and number of branch connections on one side determine the internal measurements of the inspection of chambers. Depth indicators are given in table below.

Table 1: Size of inspection chamber

Depth (mm)	Size (mm)
To 450	450*450
450-750	600*450
750-1,450	750*600
1,450 and above	1,125*750

The number of branch drains should also be considered where the distance between the centre of one drain to the centre of the next drain should not be less than 275 mm. Where the above two guidelines make it necessary to provide a very large chamber, it is advisable to provide the chamber up to a convenient height above the drains and then reduce the size to a suitable entrance chute, to reduce the cost (See also Figure 12.9 of the Appendix).

14.9 Channel

Inside the chamber the channel is as half round drain embedded in concrete that comprises the benching. All junctions must be inside the chamber, and connection is made following the direction of flow. All branch drains should always discharge above the floor of the main drain to prevent back flow of sewage into the branches which may cause blockages (See also Figure 12.10 of the Appendix).

14.10 Benching

The side of the half channels inside the chambers must provide benching. The purpose of this is to allow for the following back of sewage after a blockage has been cleared. Benching should be laid with a slope of between 20 and 30 degrees. To facilitate easy flow of sewage after clearing the blockage, the surface of the benching must be finished with a smooth cement mortar rendering.

14.11 Walls

Minimum wall thickness should be 150 mm for a chamber that is not more than 2m deep. Above 2m, the wall should be 225 mm. It should likewise be rendered smooth to easily maintain cleanliness.

14.12 Manhole Cover

Manhole covers should be of strong material, the commonest being cast iron. For chambers under roads, the cover must be heavy-duty so as to be able to withstand vehicular traffic. Triangular covers are strongest. Iron frames support manhole covers. Manhole covers may be single - or double- grooved. Double- grooved covers make the chamber airtight; hence, they are most suited for enclosed areas where odours from sewage may be a nuisance. For complete air tightness, grease may be added at the grooves on the frames. Thus, a chamber of up to 750 mm, the cover is 450*600 mm.

14.13 Backdrop

The backdrop is sometimes referred to as a drop pipe, ramp or tumbling bay. It is a type of inspection chamber provided along the drainage system where it becomes necessary to lower the level of the drain or connect a branch drain to the main drain which is at lower level. The pipe carrying the sewage that is to be lowered is fixed vertically and enclosed until it discharges on to the open drain channel at the bottom of the chamber (See also Figure 12.11 of the Appendix).

14.14 Traps and Interceptor

All drain outlets and especially inlets to soil and waste drains must be trapped. The only exception is the ventilation pipe. A trap is a device or fitting that traps water. This trapped water cuts off the drain interior atmosphere from the external air by preventing foul gases in the drain from escaping. The effectiveness of a trap is dependent on the depth of the seal, since the deeper it is, the more it will resist the pressure inside the drain.

All traps must meet the following requirements if they are to be effective:

- Simple in design.
- Accessible in all parts.
- Made of hard, smooth, impermeable material.
- Self-cleaning in action.
- Be smoothly rounded with no sharp angles or corners.
- Holding minimum amount of water but with effective seal.
- Must not retard the flow of water.

14.15 Wastewater Trap

A waste water trap is fitted at the outlet of a hand basin, sink, bath or bidet. The depth of seals depends on the type and size of the fitment but ranges between 30 mm for wash basins and 75 mm for special traps in a single system. Materials for waste water traps may be brass, an alloy of copper and zinc, PVC or galvanised iron.

14.16 Soil Water Trap

Soil water traps are from water closets, urinals or slop sinks. Soil fitments receive excreta matter so traps should effectively retain gas but not impede the flow of waste. Their minimum depth is 50 mm and may be as 75 mm for outlets serving more than five urinal stalls.

14.17 Gully Trap

A gully trap is the fitting used to receive waste water from fitments such as hand basins, sinks or baths. The purpose is to disconnect the waste or storm drain from the soil drain. It also sieves floating vegetable matter from kitchens and other food establishments. A well-designed gully trap should be self-cleaning, have a seal of not less than 65 mm and have a flat base to ensure that it is stable. It should be securely joined to the drain. The grating should have ample openings, not to impede the flow of water but small enough to prevent vegetables from going through; the grating should be protected from corrosion (See also Figure 12.12 of the Appendix).

14.18 Grease Trap

Some establishments like hotels, hostels, cooking oil and fat processing plants and other food industries produce waste water that contains large amounts of greasy matter. This matter tends to clog the sides of cloak pits and interfere with the digestion process of septic tanks and other treatment units. The purpose of a grease trap, therefore, is to prevent this matter from passing through the drain. Grease traps are of different shapes and sizes, but the principle of extraction is the same where grease and oils float to the top and are scooped off manually (See Figure 12.13 of the Appendix).

14.19 Intercepting Trap

An intercepting trap is also known as a disconnecting trap. It is fixed along the house drain, in the last manhole before the drain joins the sewer. The purpose of this trap is to disconnect the house drain from the sewer to prevent foul gases and rodents from entering the private drainage. A fresh air inlet is provided in the manhole where this trap is fixed. This device allows fresh air to flow inside the house drainage system and escape through the ventilation pipes at the highest manholes, thus removing foul gases from the drain (See also Figure 12.4 of the Appendix).

14.20 Petrol Interceptor

Petrol stations and garages produce a lot of waste petroleum products which may interfere with the self-cleaning processes of water bodies. They also interfere with sewage treatment processes where waste is discharged into sewage work stand may even cause explosions. Traps known as petrol interceptors remove this waste. The principle of operation is similar to a grease trap. The only difference is that the tanks are airtight, and petrol fumes are collected by a pipe which disperses the gas into the atmosphere.

14.21 Road Gully

A road gully is used to take in storm water. It is connected in such a manner that a sump or mud-well is provided at the bottom for receiving heavy solids such as gravel which are frequently removed. Road gullies should be placed 40 to 50 metres apart. Materials used to make gullies may be iron, stoneware, dressed, stone, and concrete or bricks. The shape may be circular, square or rectangular. They should meet all the requirements of a good trap. Most gullies are located on roads with vehicular traffic. They should therefore be able to support a heavy grating at the top.

14.22 Ventilation and Anti-siphon Age

All drain inlets must be trapped to prevent foul gases from entering the living areas. For this to be effective, the minimum depth of water seal in trap should be 30 mm. Traps may be rendered ineffective due to evaporation, that is, staying too long without use or replenishing, or when no anti-siphon age pipes are provided. Air compression or drain ventilation may not be effective. There may be lack of momentum due to strong flow or capillary attraction when a piece of rag rests in the trap.

To prevent ineffective drainage, ventilation of drains by anti-siphon pipes must be provided. Anti-siphon age pipes are connected to the main vent pipe or rise on their own to the top of the building and open to the atmosphere. The underground drains are also ventilated by means of a pipe fixed at the last or highest manhole. This prevents raising the air pressure in the drains. The vent pipe should not be reduced in diameter if it receives waste. If it does not receive any waste, it could be provided with a pipe of less diameter (up to 40 mm) (See also Figure 12.15 of the Appendix).

14.23 Design and Testing of Drains

After the working drawings are ready and have been approved by the relevant authorities, construction of drains can start. In so doing, pegging of the drain lines and manholes is done. Before digging starts, the slope or gradient of individual drain sections is fixed by the use of peg lines. These are facilitated by boning rods and sight rails. Digging of the trenches normally starts with the manholes. Drain pipes are laid with the sockets facing upwards and spigots downwards.

Once a new building is complete, it requires to be inspected by the relevant authorities to ascertain that it has been constructed in accordance with the approved plans. One of the important areas to be inspected is the drainage system. A test is undertaken depending on the availability of testing materials and equipment (See also Figure 12.16 of the Appendix).

14.24 Water or Hydraulic Test

A water test is the commonest and most reliable. It relies on pressure of water inside the drain. It is therefore very suitable for new drains. The procedure is that the lower end of the drain section being tested is plugged at the entrance of the lower inspection chamber. All inlets into the upper manhole are also plugged. Water is then put into the drain from the upper manhole and filled up to a level that is marked. The level obtained must be maintained for a minimum of 30 minutes before any notable change (15 minutes are allowed before the level is marked for wall absorption of water). Each section (branch) is tested separately. If the upper sections are done

first, the same water can be used to test the lower sections (See also Figure 12.17 of the Appendix).

14.25 Smoke Test

A smoke test uses a smoke rocket or special drain testing machine (smoke generator). In both cases, both ends of the drain section being tested are plugged and smoke introduced through the lower end. Detection of leaking joints is visual. Smoke may be observed escaping through the loose joints. With the smoke rocket, a smoke-producing stick or pellet is lighted and placed at the lower end of the drain section for smoke to rise up the drain. A smoke testing machine produces and forces smoke into the drain and in so doing raises the air pressure in the drain. Escape of the smoke will be visible as the pressure indicated by the machine lowers.

14.26 Ball Test

The ball test checks the smoothness of the drain for continuous flow of sewage. A hard wood or plastic ball is pushed through the upper manhole; as it rolls down, it should move noiselessly towards the last manhole. Any obstructions due to protruding jointing material or misalignment of the drain will be easily detected.

14.27 Coloured Water Test

The main objective of the coloured water test is to detect if the sewer contents gain access to nearby water bodies, especially ground water. Water containing chemical fluoresce in (which gives a vivid yellowish-green colour) is poured into the drain. If there is any leakage along the drain, the colour will be observed in the ground water. This chemical is detectable even in very dilute form. It is a test that can be used to determine if pit latrine or soak pit contents gain access to a nearby shallow well.

14.28 Drain Testing Equipment

Drain plugs are made of stout rubber rings held between two galvanised iron discs. When the two discs are squeezed together by a nut, the rubber expands outwards and passes against the walls of the drain, making it watertight and airtight. A bag stopper consists of an airtight rubber bag encased in canvas with a rubber tube attached. This rubber tube allows the bag to be inflated by means of a hand pump until it is tight in the drain. A strong rubber disc plug slightly larger than the diameter of the drain makes the blockage watertight. A Leacock drain-testing appliance is used between the disconnecting manhole and the sewer. It consists of a bag stopper attached to a long air tube. It is mounted on a drain rod with wheel attachment. It becomes a mobile stopper that can be rolled down the drain to the required position where it is then inflated to close the drain.

14.29 Drain Clearing

A well-constructed and well-maintained drainage system should not choke up. Blockages may, however, occur along the drains, and these are best removed by drain rods of good quality Malacca or other suitable cane. The canes are obtainable in various lengths and are joined into convenient lengths at the end of which a

suitable tool is fixed. To prevent rods getting lost in the drain, they are joined by locking joints. To facilitate easy satisfactory Roding, distances between especially where it becomes necessary to negotiate bends and traps. The tools used in drain clearing are:

- Single clearing wheel- prevents ends of rods from hooking in joints or angles of pipes.
- Double spiral spring-clean pipes choked with rags, papers, etc.
- Plunger- made of sole leather or India rubber with brass cup and screw for plunging the drain.
- Whalebone brush- cleans pipe.
- Jointed or drop scraper-cleans neglected drains.
- Malacca cane- are normally bound together by a pair of leather straps to permit easy transportation; used for clearing blockages (See also Figure 12.18 of the Appendix).

14.30 Drain Fitments and Fittings

Drain fitments vary considerably according to materials, shape and use.

14.31 Soil Fitments

The soil fitments receive excretal matter from the water closet, urinal and slop stopper.

14.32 Water Closet

A water closet is a lavatory or fitment used to receive human excreta. All water closets should meet certain requirements. The pan, basin and any other receptacle should be of non-absorbent material such as porcelain. It should be constructed and fitted to receive and contain sufficient water and allow any excreta to fall free of the sides and directly into the water. The flushing apparatus should be such that prompt, effectual and thorough cleaning of the pan is attained. Where the discharge pipe receives discharges from another fitting or fittings, the trap of the closet should be properly lighted and ventilated. The minimum depth of the water seal is 50 mm.

The commonest materials used for making water closets are vitreous china clay, enamelled fireclay and glazed earthenware. Vitreous china clay is the strongest and best.

Water closets have evolved from very poorly designed obsolete types such as the pan closet, long hopper, short hopper and wash out to the modern wash down symphonic type. Wash down water closets are designed so that discharges fall into a large body of water. The basin design is such that it can be effectively cleaned and squatting type. The pedestal is fixed above the floor level to enable one to sit while depositing excreta. It is a very convenient type for the old and sick due to its comfort. It is not approved for public places as people misuse it by stepping on the seat, making it inappropriate and unhygienic for use. The squatting type is fixed at the floor level for one to squat while depositing excreta. Since the human body does not come

into contact with the pan, it is more hygienic and ideal for public places. It is, however, uncomfortable for the sick and the old.

Public health acts and buildings by-laws stipulate that water closet cubicles must meet certain requirements. Each cubicle should have minimum dimensions of 1.5 m long by 0.8 m wide. No water closet cubicle should communicate directly with any living room other than a bedroom or dressing room. All buildings, both private and public, should be provided with adequate and satisfactory latrines (See also Figure 12.19 of the Appendix).

14.33 Urinal

Urinal is a fitment that must be provided only on the male side of a sanitary block for the purpose of receiving urine. Its provided in lieu of a water closet. A urinal is not necessary in a private dwelling but its required in all public toilets including business premises that receive many customers.

Urinals are of three types: basin (or bowl), stall and slab. All three must be made of non-absorbent material (preferably white glazed fire clay) and have adequate flushing arrangements that prevent fouling of surfaces. They should not have sharp corners or crevices capable of accumulating filth and should provide sufficient privacy. The basin type is suitable for individual use. The fitment is a basin or a bowl that is fix on the wall. its normally made of white glazed fireclay. The stall type is also made for individual use. It is comprised of an individual unit to accommodate one person but more than one may be arranged in a line for several users.

Material is usually white glazed fireclay. Each stall is trapped separately. An alternative material is concrete made into a slab but partitioned with short walls of about 150 mm projections. In this case, each slab should be about 600 mm wide for one person. A channel may be provided at the bottom to discharge urine towards a trapped outlet. The slab type is in the form of a wide slab placed or constructed along the wall but with no partitions. It is used by many people at the same time. It should be drained by means of a channel fixed at the bottom that drains towards an outlet at one side. It is suitable for institutions where users are of almost the same age as it lacks privacy.

Urinals are usually provided with automatic cisterns of about 4.5 litres which flush approximately every 20 minutes. To provide effective flushing, basin and stall types of urinals are provided with individual flushing cisterns. The slab urinal is provided with a large flushing cistern on to which a horizontal pipe called a spreader is fixed that distributes flush water along the slab surface. Urinals should discharge through a trap to a soil drain. The trap should be provided with a grating at the inlet that is made of gunmetal or brass. The grating prevents choking of the trap by extraneous matter

Rooms housing urinals should be adequately ventilated and lighted. Floors and walls should be smooth, hard and non-absorbent; they may be finished with smooth cement, marble tiles or terrazzo. Floor level should slope towards the outlet.

14.34 Slop Hopper

A slop hopper is also known as a slop sink, slop closet or sluice. It is commonly used in hospitals, institutions and hotels where it is fitted in the sluice room. It drains off

soil matter from bathrooms, bedrooms and wards. It may be combined with a housemaid's sink to make it easy for soiled clothes and other articles to be washed and faecal matter flushed off. Hot and cold water are essential in this fitment. It is usually made of white glazed fireclay (See also Figure 12.20 of the Appendix).

14.35 Waste Water Fitments

Waste water or ablutionary fitments receive waste water which has no faecal matter. They include lavatory or hand basin, sink, bath, bidet and drinking fountains.

14.36 Lavatory Basins

Hand wash basins or lavatories are mainly made of vitreous china clay, glazed earthenware, glazed fireclay, enamelled cast iron, plastic (thermo-setting type), stainless steel or stoneware.

The standard type of lavatory basins in the market is 550*400*150 mm or 625*450*150 mm; corner types also vary in size. Their waste outlets range from 30 mm to 45 mm in diameter and pass through a trap with a minimum of 40-mm deep seal. They are fitted with overflows which must connect with the outlet pipe before the trap. Lavatory basins are placed in lavatories, bathrooms, bedrooms, kitchens and any other place where hand washing is necessary a few of them are of pedestal type rest or are fixed on the floor, but the majority are fixed on walls supported by cantilever brackets. In public buildings, school or factories where a range of basins is fixed, they may discharge into a half-round channel which leads to a gully trap at one end. In this type of arrangement, trapping of individual basins may be omitted (See also Figure 12.21 of the Appendix).

14.37 Sink

Sinks are generally made of fiberglass, glazed fireclay, concrete, cast iron or aluminium. They may also be made from those materials used in making lavatory basins. A scullery sink has drain boards for draining utensils. A pantry, wash-up butler's sink is made of hardwood. A drip sink is provided in bathrooms to receive drips from taps or buckets. Sinks should be provided in kitchens where food is cleaned and prepared, on pantries where crockery and utensils are washed, in laundries for washing of clothes and in other places (like laboratories) where washing of various articles is done.

Waste outlets and overflows are used for lavatory basins. They are supported by cantilever brackets or dwarf walls. Drain boards are important fixtures fitted to the sink for draining the washing utensils. They may be on one side or both sides. The material may be either of the same material as the sink where the board is an integral part of the sink or may of hardwood, concrete or corrugated iron. They are fitted **so as to fall towards the sink to allow waste water to run off quickly. Concrete material for either sink to allow or drain boards is very unsuitable as it is very difficult to keep clean and it chips crockery.** The wall immediately behind the sink should be lined with impervious material; glazed tiles or cement mortar. The space between the back of the sink and wall should always be made watertight to prevent seepage sink are normally of the following sizes; 750*450*250mm, 600*450*250mm, 750*525*250mm or 600*525*250mm (See also Figure 12.22 of the Appendix).

14.38 Baths

Baths are essential in every dwelling and any other premises requiring bathing either before or after work. They are of two types; shower bath and plunge bath. The plunge bath is best made of enamelled cast iron. Other materials include white clay, fireclay, vitreous china clay and fiberglass. They are commonly marketed in the following sizes; 1,650*700*450mm and 1,400*725*150mm. Other smaller sizes and different shapes (oval, round) can also be found. Baths are usually provided with brass outlet traps supplied with the fitment. Their sizes range from 40 to 50 mm diameter with 40 to 75 mm depth of seals. Overflows must also be provided. A properly constructed bath is raised above ground to give room for waste pipe and trap. A good bath should be free from all corners and angles, have non-corrodible but smooth surfaces, be light but durable and should not absorb an undue amount of heat.

Showers are provided with an overhead or wall spray and fitted a gate valve to control the flow. The spray may be incorporated in plunge bath with option of using plunge or spray. The outlet is fix on the floor and provided with a brass grating. Minimum size of a shower room is 3 square m, with a minimum width of 1m.

For a shower to be sanitary, it should be constructed in a certain manner. The floor should be of impervious material such as concrete or terrazzo. It should be non-slippery and self-draining to the outlet. The wall should be rendered smooth with PVC. Tiles, porcelain enamelled tiles or concrete and be a minimum of 1,500 mm high. The outlet should be properly trapped and the room well-lighted and ventilated.

Like plunge baths, showers are provided with hot and cold water which may be controlled by a combination or mixing tap. The tap enables one to control the temperature of the water needed. Showering is facilitated by providing a shower hose that is either fix on the wall above the head or on a plastic spring -coiled tube known as a “go –anywhere “ shower or “ miracle shower“. To prevent watering of the whole bathroom, a plastic curtain is suspended on rails at above- head height; it hangs down inside the plunge bath.

14.39 Bidet

The bidet is a fitment resembling pedestal water closet but provided with water nozzles facing upwards. It is used to facilitate washing the anal region and genitalia. Water jets are directed upwards and the washing is done in a sitting position. Hot and cold water are provided, and the outlet is fitted at the bottom (see Figure 12.24 of the Appendix). The fitment is made in one piece of glazed vitreous China clay.

14.40 Flushing Tank (Cistern)

The main purpose of the flushing tank or cistern is to prevent water wastage in toilets and at the same time conserve enough water to flush the water closet or urinal effectively. Depending on the type of cistern, flushing is effected by manually pulling the chain or turning the lever or pushing the button: an action that releases a predetermined amount into the fitment. There are many different types of flushing cisterns, but the commonest in the market are bell type, piston type and automatic cistern.

The basic operational principle for the three types is the same, where the apparatus takes the shape of a “U”. Flushing is affected by pushing water over the crown of the u-shaped apparatus, thus breaking the siphonage. This then allows all the water in the tank to flow through to the toilet. All flushing cisterns may be made of ceramic materials, painted cast iron, enamelled vitreous china, PVC, asbestos fibre or glass fibre.

The ball type of cistern uses a symphonic apparatus that takes the shape of a U-tube or bell, and the flushing pipe forms the long arm. Water fills the tank to a pre-determined level where as it fills the tank; after reaching a particular level, it stops the flow all together. To flush, the bell-shaped apparatus is lifted then dropped back into position by releasing the chain. This action forces water trapped in the bell to flow over the top of the flush pipe and so break the siphonage. The capacity is normally 9 litres.

The piston type cistern uses a piston or plunger to push a small quantity of water over the crown of the U-shaped tube. This action then starts siphonage action. The ball valve is similar to the bell type valve. Capacity is also normally 9 litres.

An automatic cistern is similar to the other two cisterns but it is not manually operated. It therefore breaks its own siphonage. The fitting is used in urinals or in channel closets where excreta are deposited on a long channel and flushing is done at pre-determined intervals. The fitting has therefore no ball valve and the interval of flushing is determined by controlling the flow of incoming water. In urinals, the size of the tanks is normally 4.5 litres and the flushing interval controlled to 20 minutes.

Low level tanks are slowly replacing the high head chain operated tanks. Instead of the chain, the flushing apparatus is modified to a hand lever. The basic flushing principle is the same with the piston type unit. Since the low level flushing pipe is not high enough to provide the desired velocity, as is provided by the chain operated type, the internal diameter of the flush pipe is slightly increased to give the same effect.

Special mechanical valve-operated devices permit a pre-determined quantity of water to pass in order to flush the closet without the use of a flushing tank. The fitting is relatively less noisy and is operated by a push knob or small lever, both of which are self-closing. They are fitted directly on to the supply pipe. Care must be taken using this device to prevent back siphonage which may contaminate the drinking water supply.

15. Duties of the Public Health Officer

A Public Health Officer (PHO) is empowered by various acts, building codes and by-laws to access and determine their appropriateness of any silting of premises that is meant for human occupation and give relevant advice or directives. A PHO also examines building plans and gives appropriate decisions in conformity with relevant laws.

Inspection of ongoing construction meant for human occupation is necessary to ensure safety, comfort and welfare. Existing building structures are inspected to ensure the conformity with relevant laws.

Public Health Officers should take any decision as may be appropriate to safeguard their health, welfare and comfort of the occupants of any premises.

List of Abbreviations

CD:	Candela
DPC:	Damp proof course
DPM:	Damp proof membrane
PHO:	Public Health Officer
PVC:	Polyvinyl chloride

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Appendix

Water Services Trust Fund

Public Sanitation

Construction Supervision Guidelines and Procedures Manual

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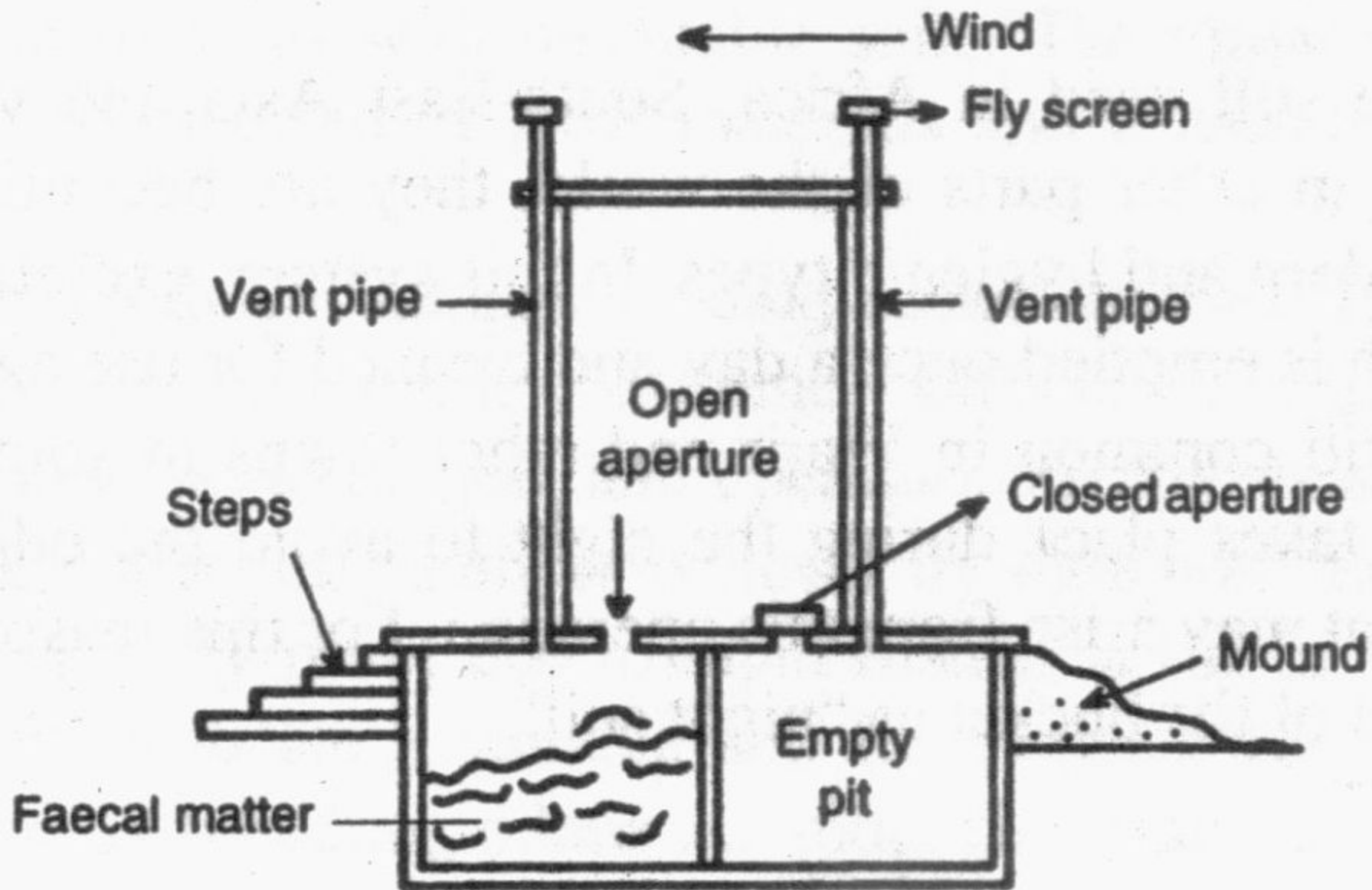


Figure 5.6 Alternating double pit latrine

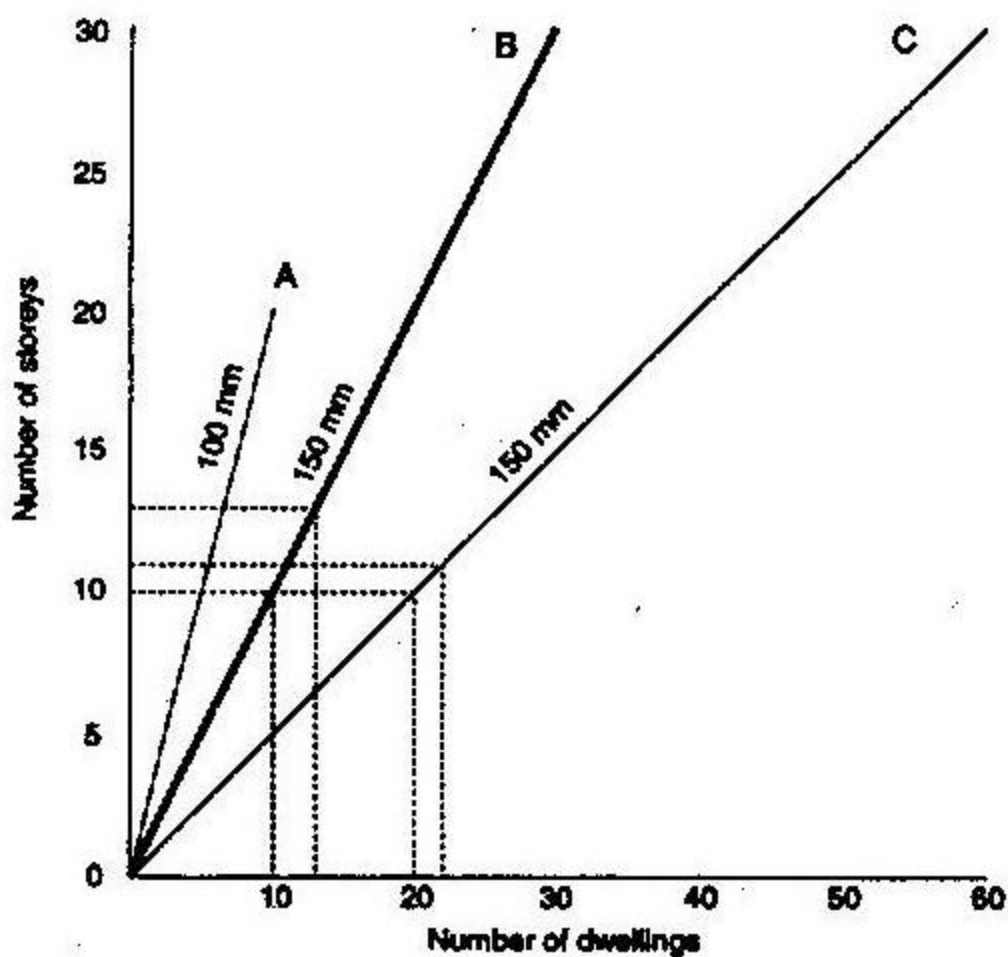


Figure 12.3 Graph showing recommended stack diameters for various loading conditions and storeys

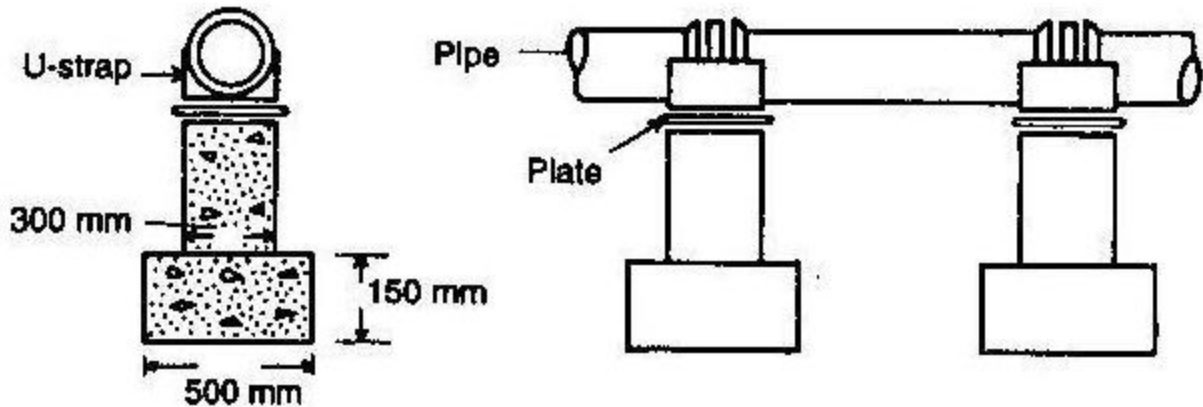


Figure 12.5 Support for a cast iron pipe on unstable ground

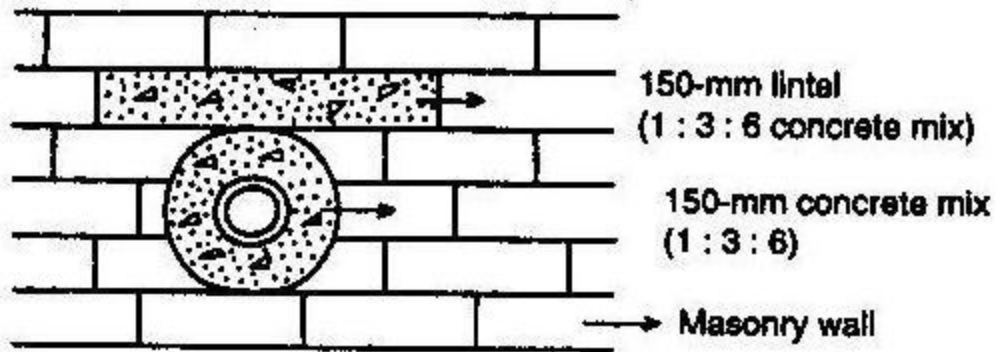


Figure 12.6 Protection of drain through a wall

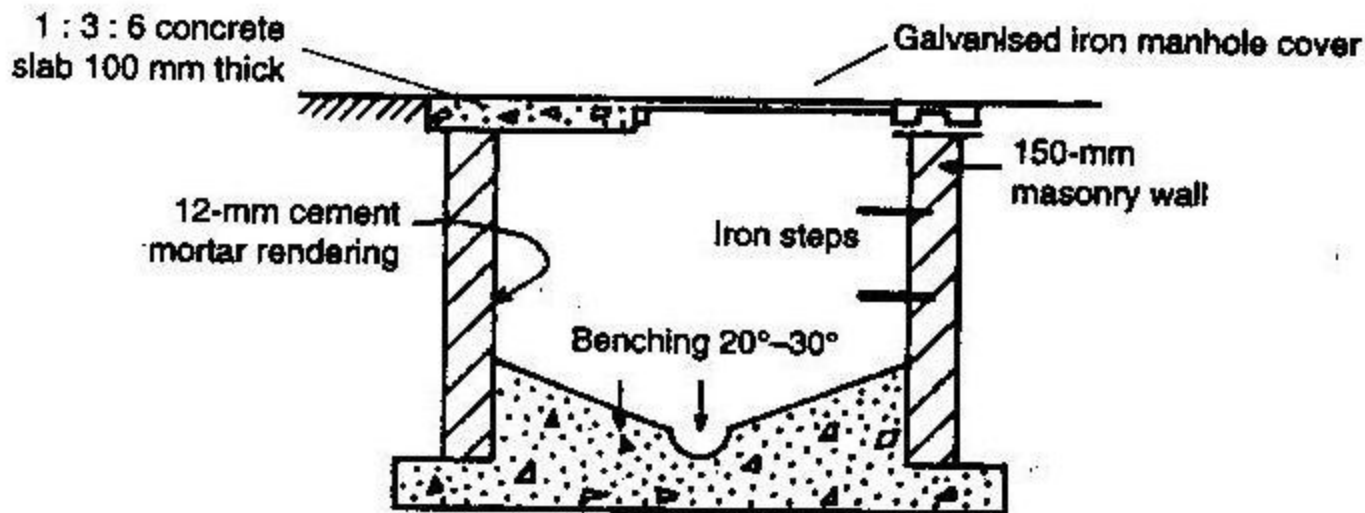


Figure 12.7 Cross section of inspection chamber

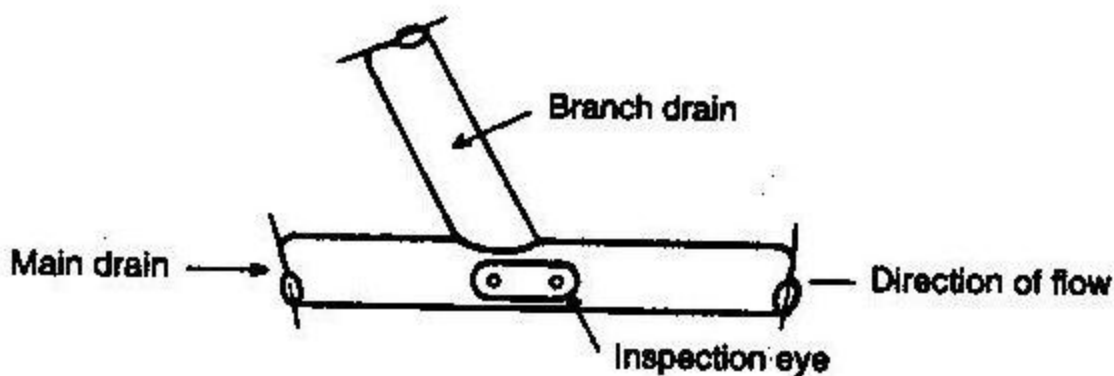


Figure 12.8 Inspection eye

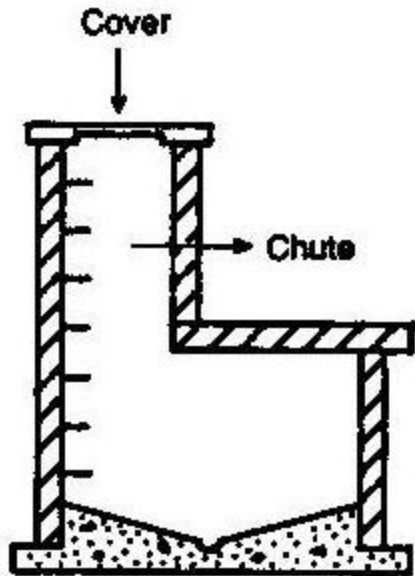


Figure 12.9 Inspection chamber with entrance chute

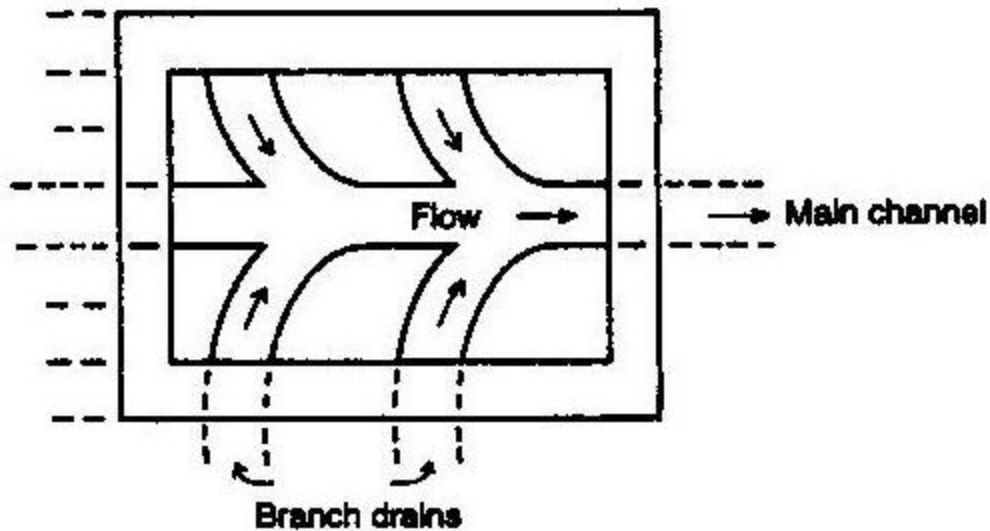


Figure 12.10 Drain junctions inside an inspection chamber

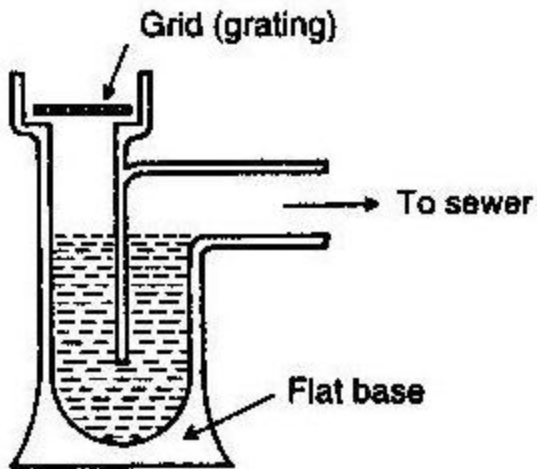


Figure 12.12 Gully trap

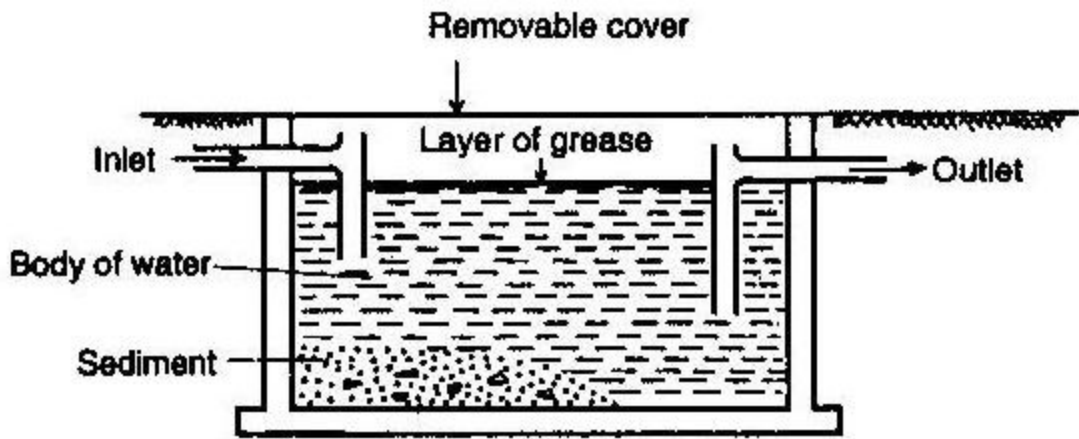


Figure 12.13 Grease trap

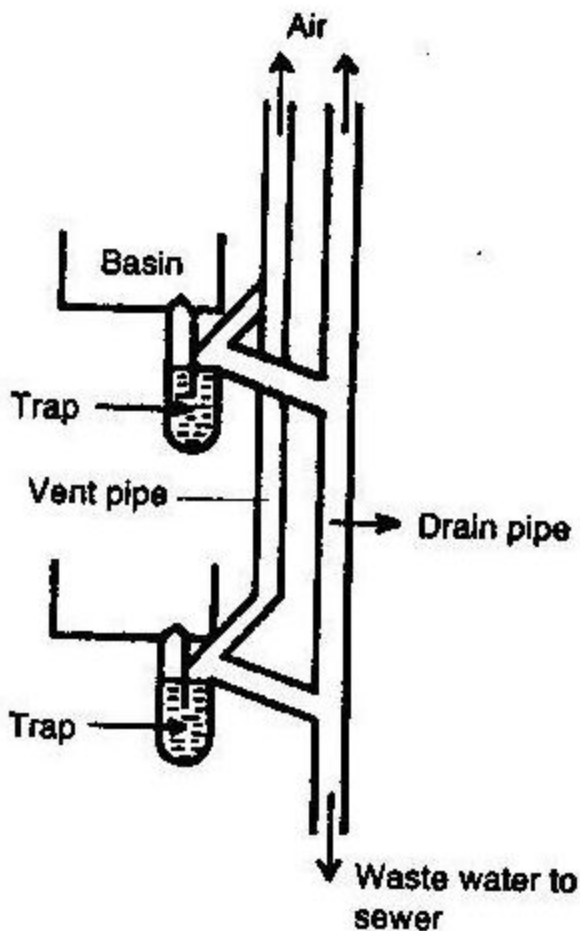


Figure 12.15 Anti-siphonage pipes

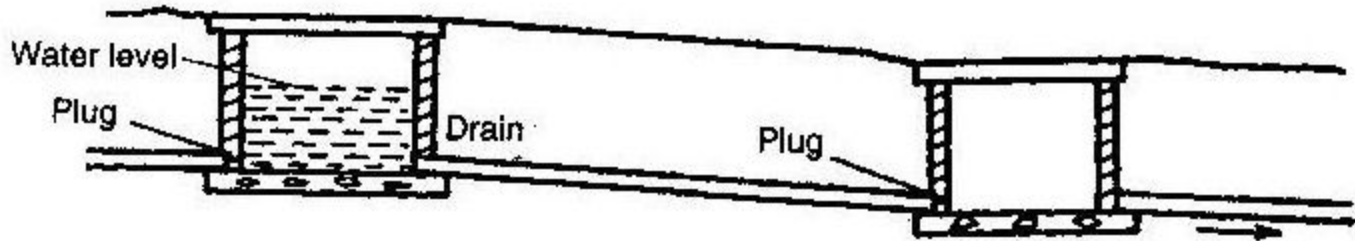


Figure 12.17 Water test

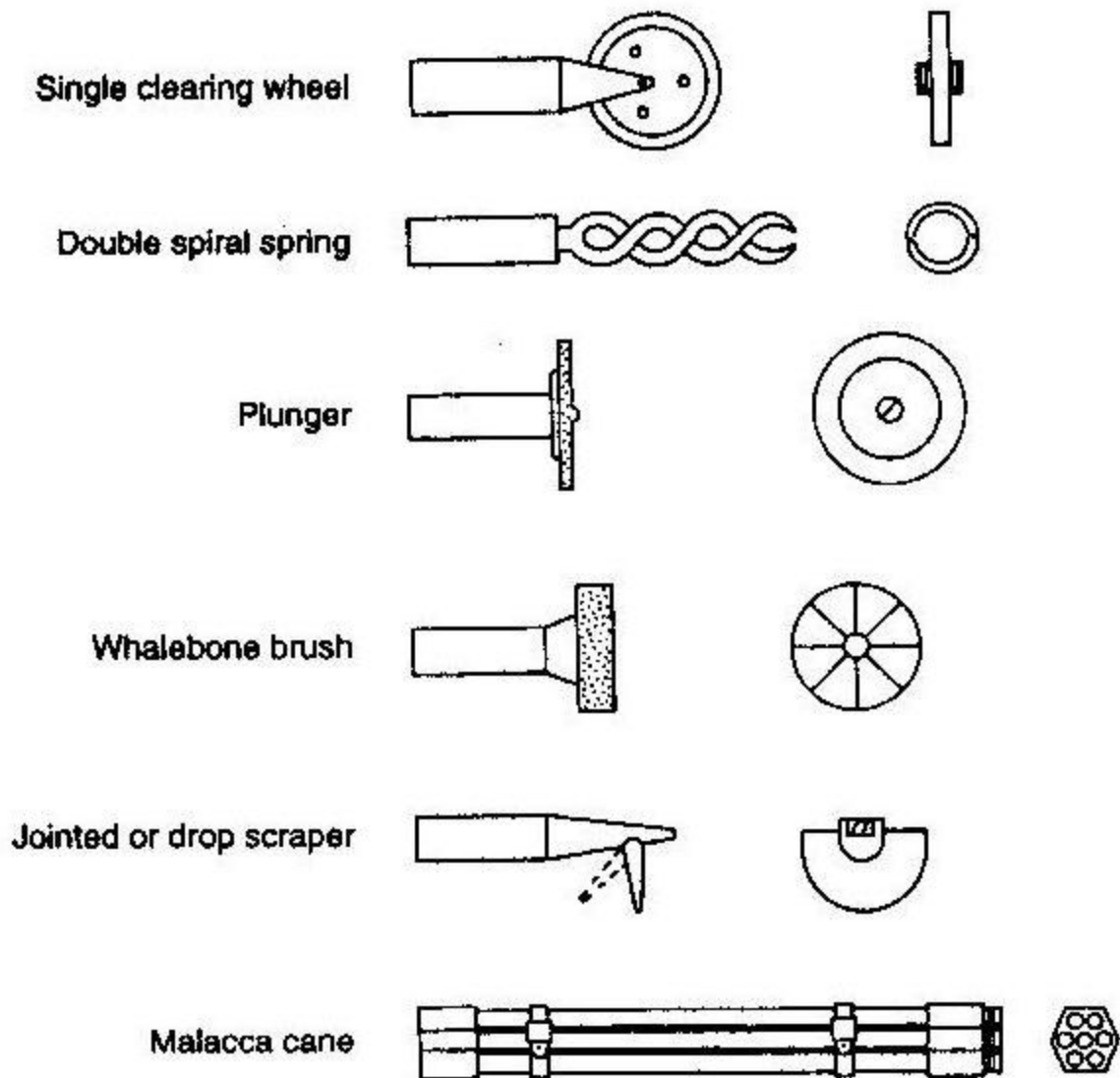


Figure 12.18 Drain clearing tools

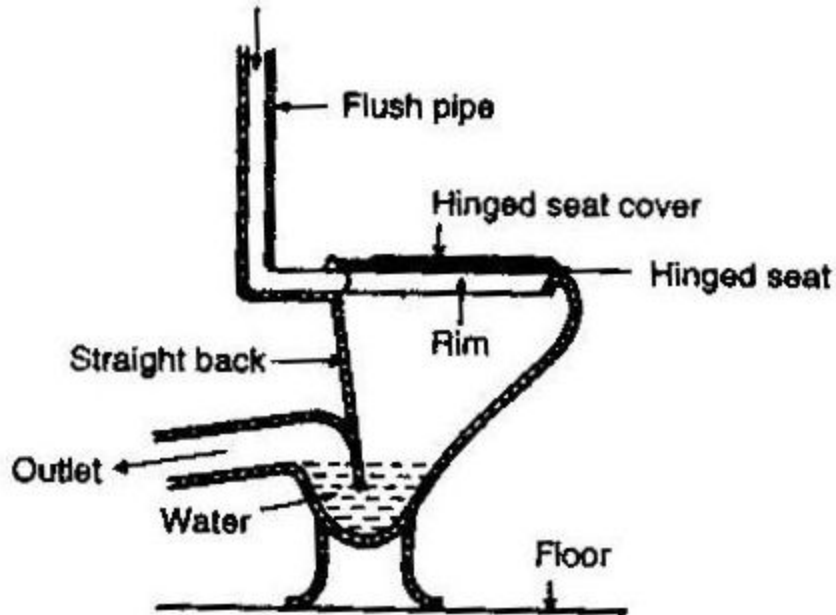
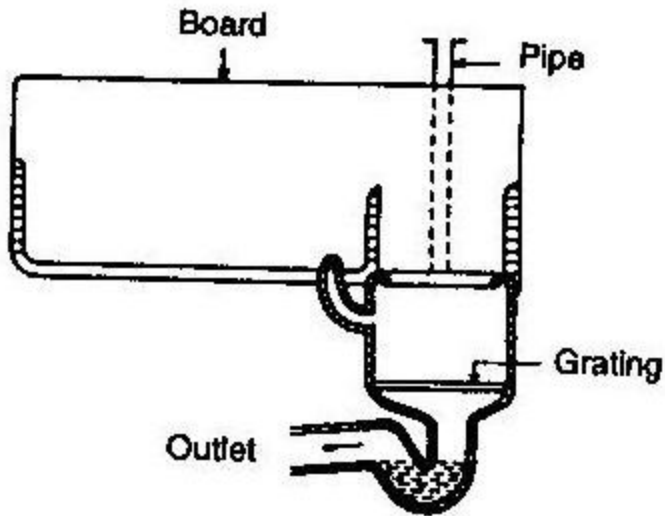


Figure 12.19 Pedestal water closet



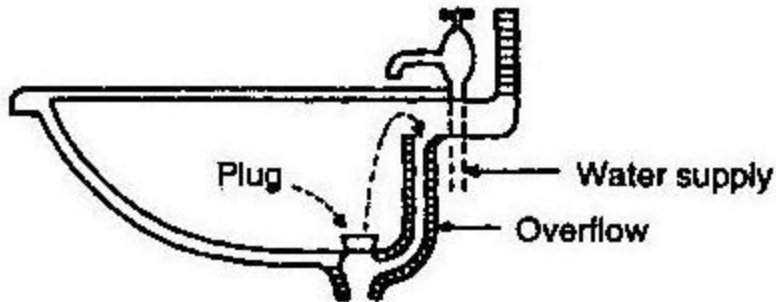


Figure 12.21 Lavatory basin

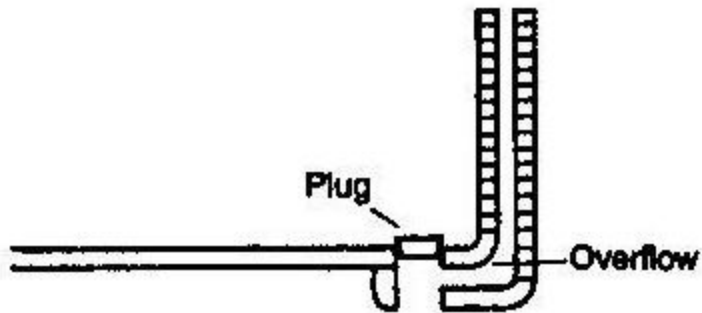


Figure 12.22 Fireclay sink

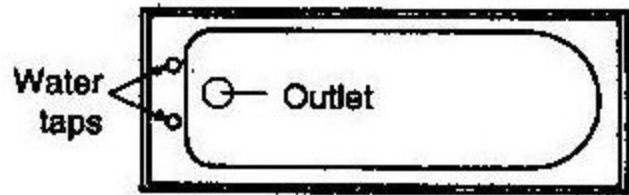
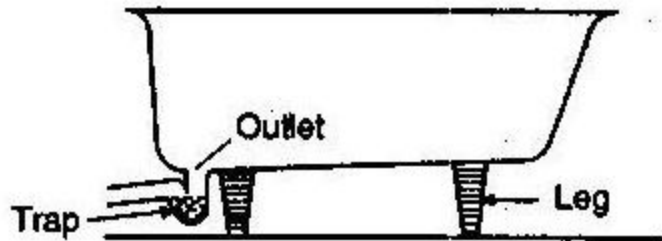


Figure 12.23 Plunge bath

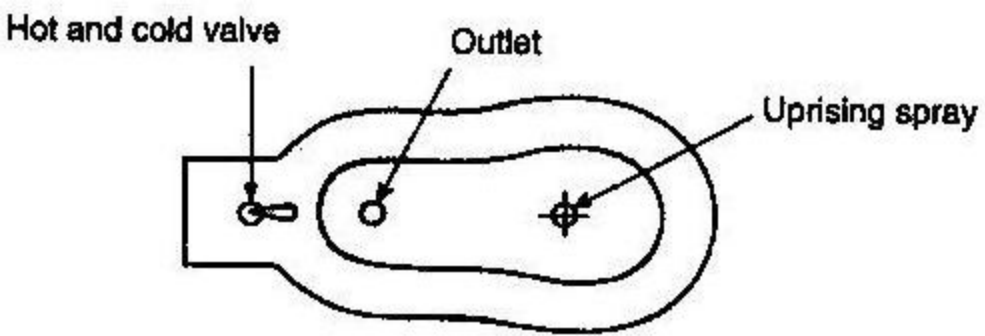


Figure 12.24 Bidet

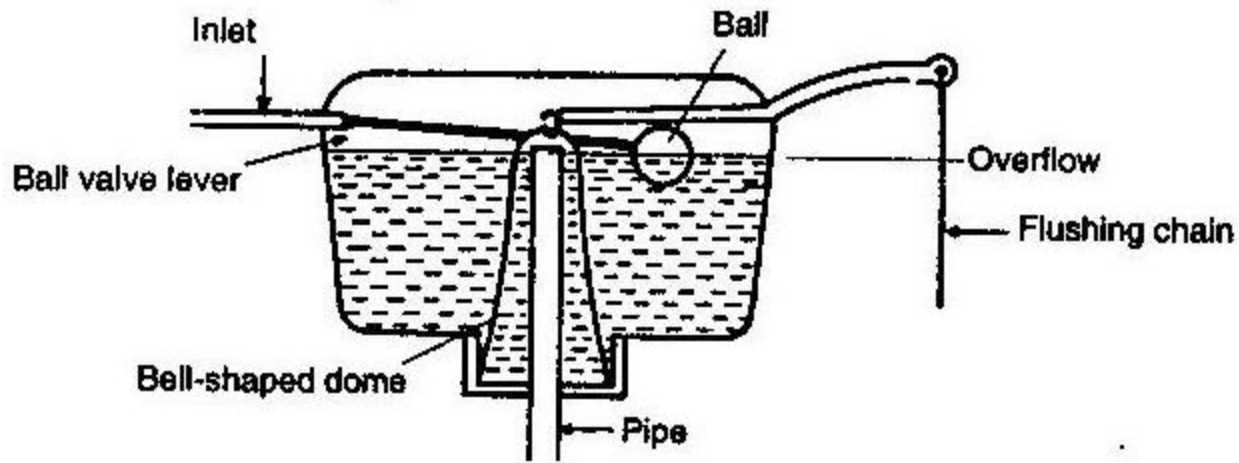


Figure 12.25 Ball type cistern

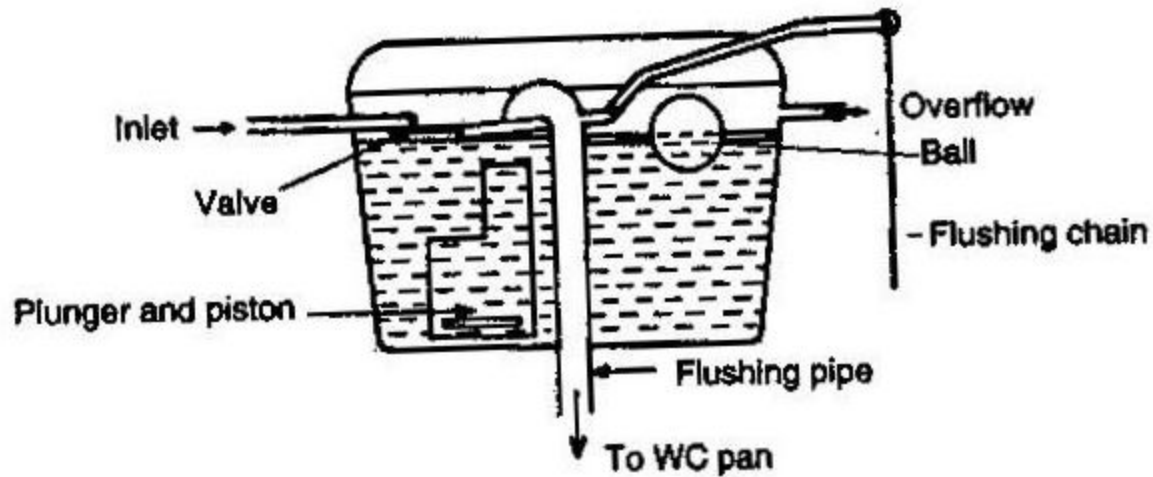


Figure 12.26 Piston type cistern

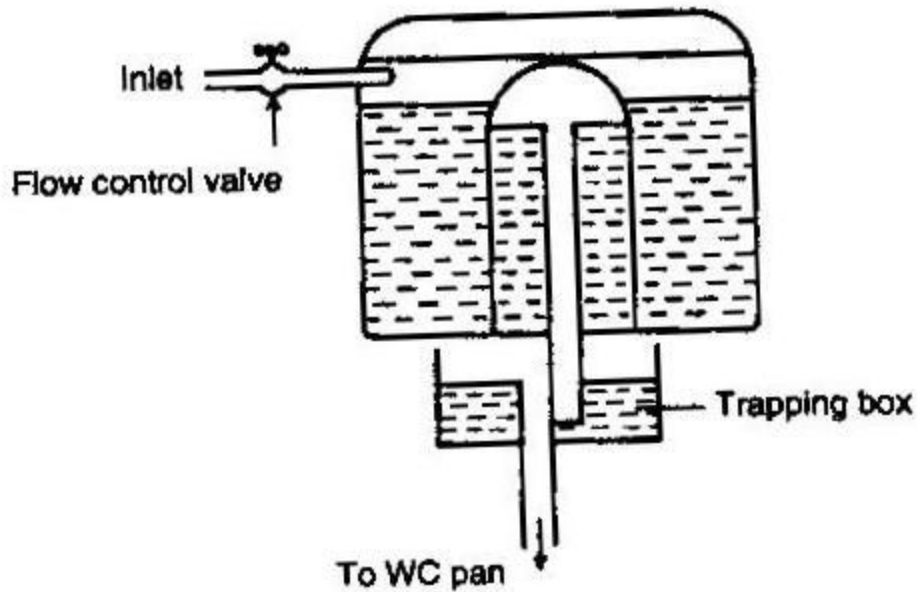
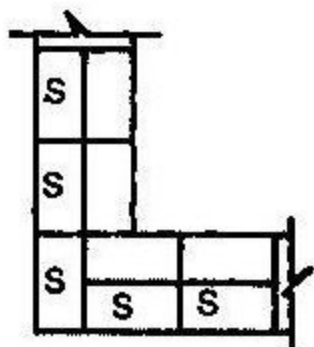
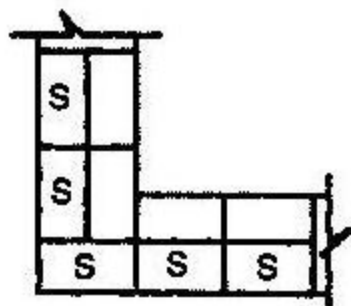


Figure 12.27 Automatic cistern

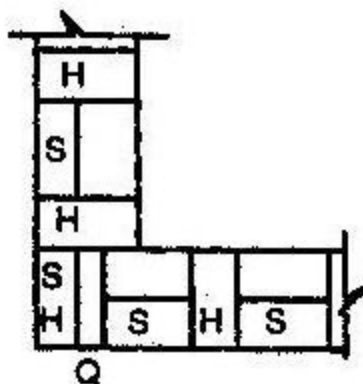


Plan: 1st course

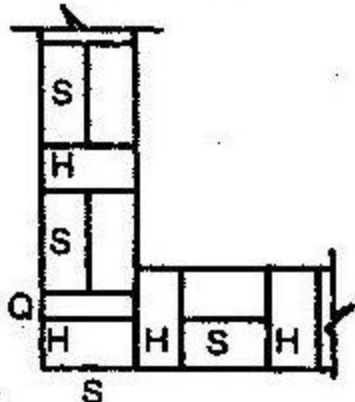


Plan: 2nd course

Plan: 1st course



Plan: 2nd course

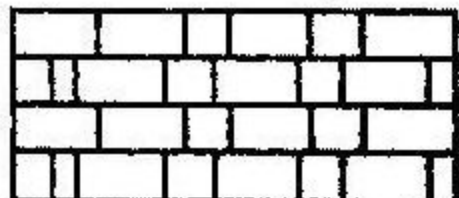


Elevation



Stretcher bond: one-brick wall

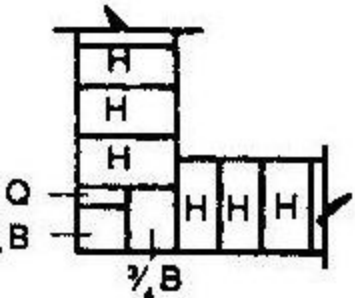
Elevation



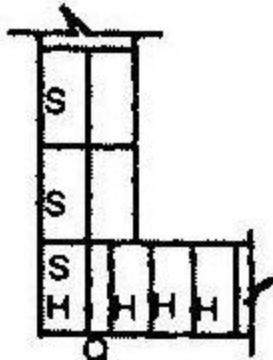
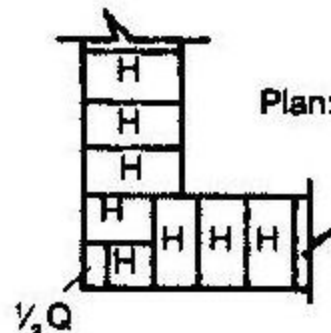
Flemish bond: one-brick wall

Key
 H = Header
 S = Stretcher
 Q = Queen closer
 $\frac{1}{2}B$ = Half bat
 $\frac{3}{4}B$ = Three-quarter bat
 $\frac{1}{2}Q$ = Half queen closer

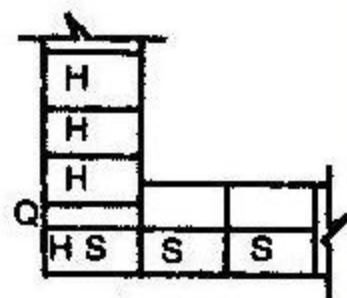
Plan: 1st course



Plan: 2nd course

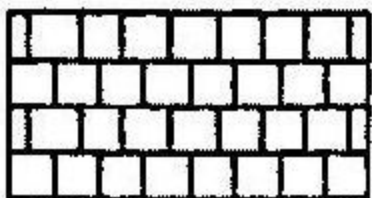


Plan: 1st course

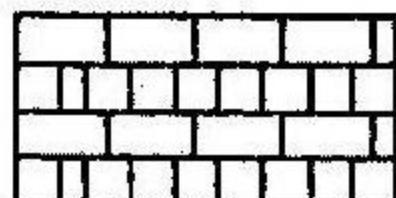


Plan: 2nd course

Elevation



Elevation



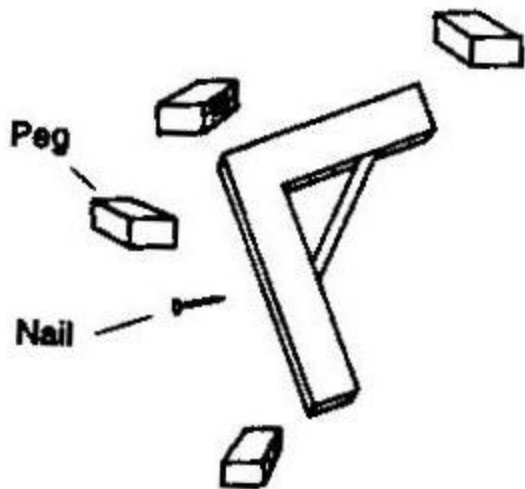


Figure 11.1 Builder's square

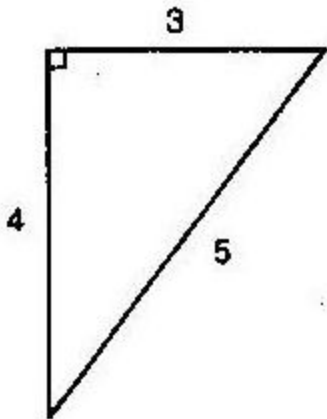


Figure 11.2 Pythagorean theorem

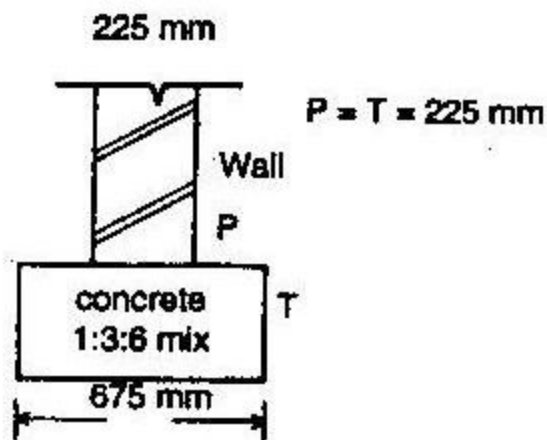


Figure 11.3 Common strip foundations

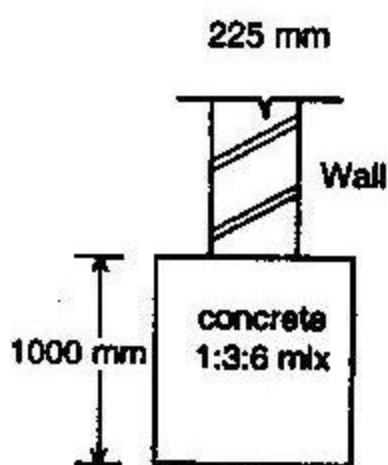


Figure 11.4 Deep strip foundations

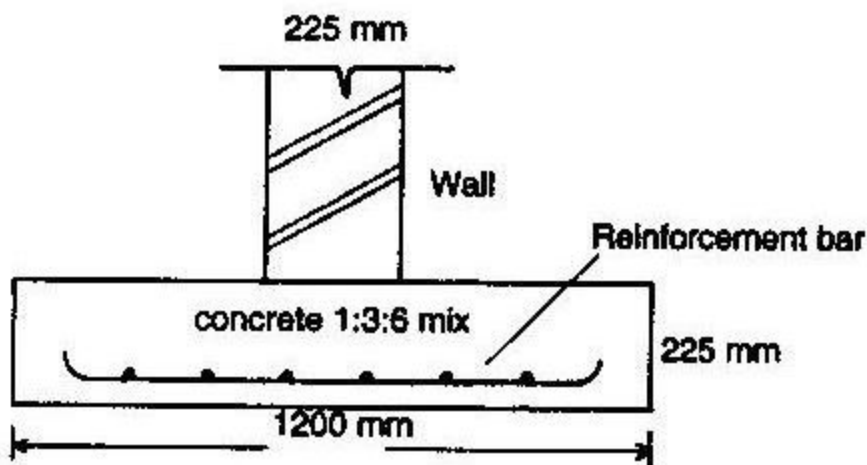


Figure 11.5 Wide strip foundations

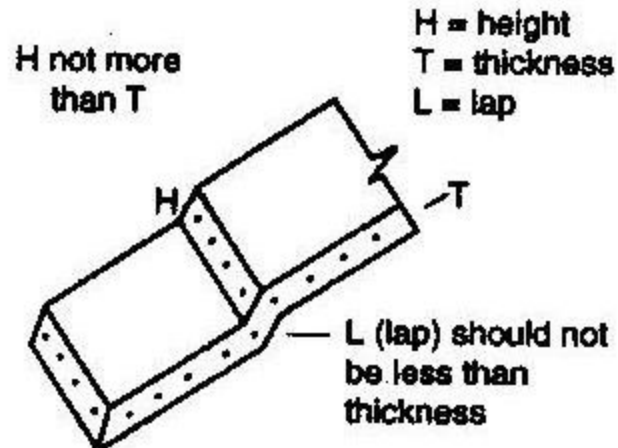


Figure 11.6 Stepped strip foundations

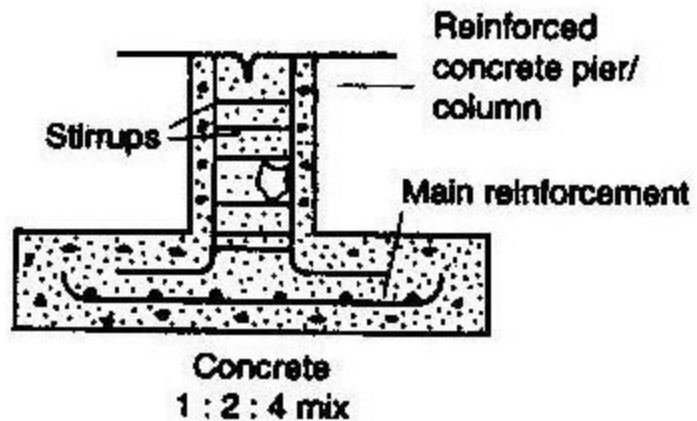
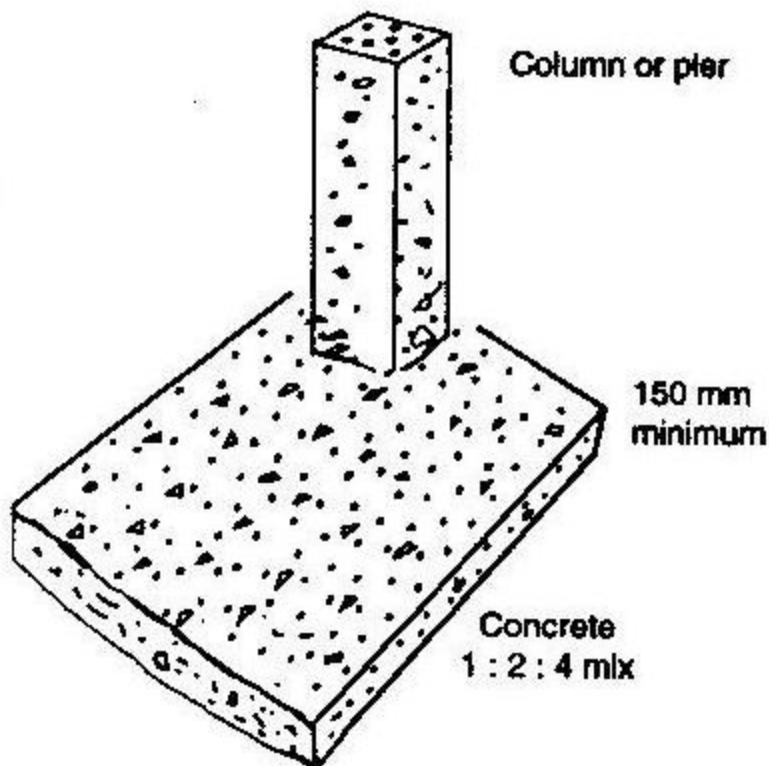


Figure 11.7 Pad with column/pier (left) and section of reinforced pad with a column/pier (right) foundations

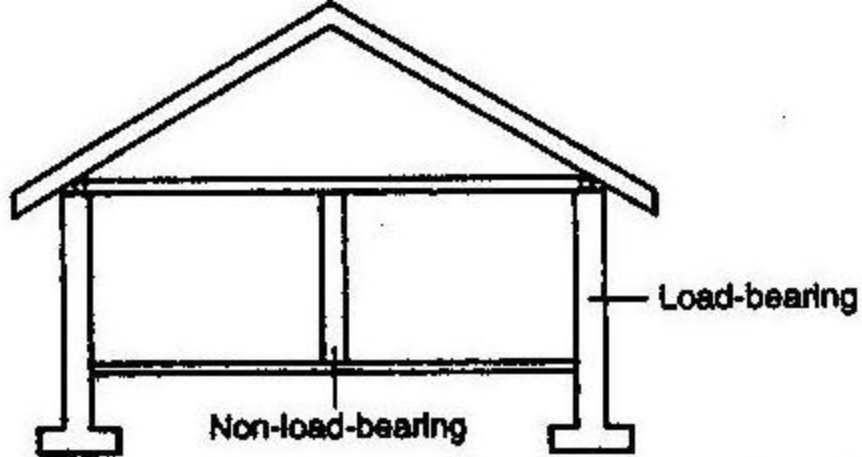


Figure 11.10 Load-bearing and non-load-bearing walls

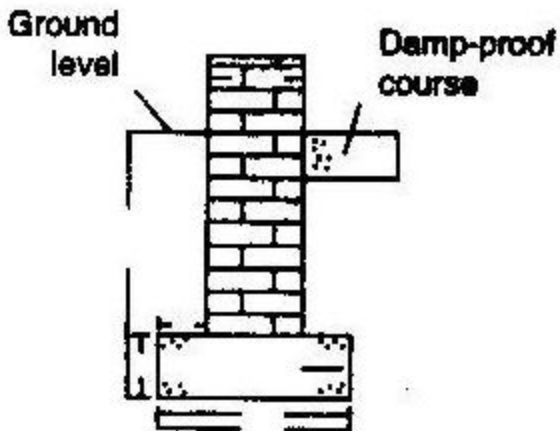


Figure 11.12 Damp-proof course

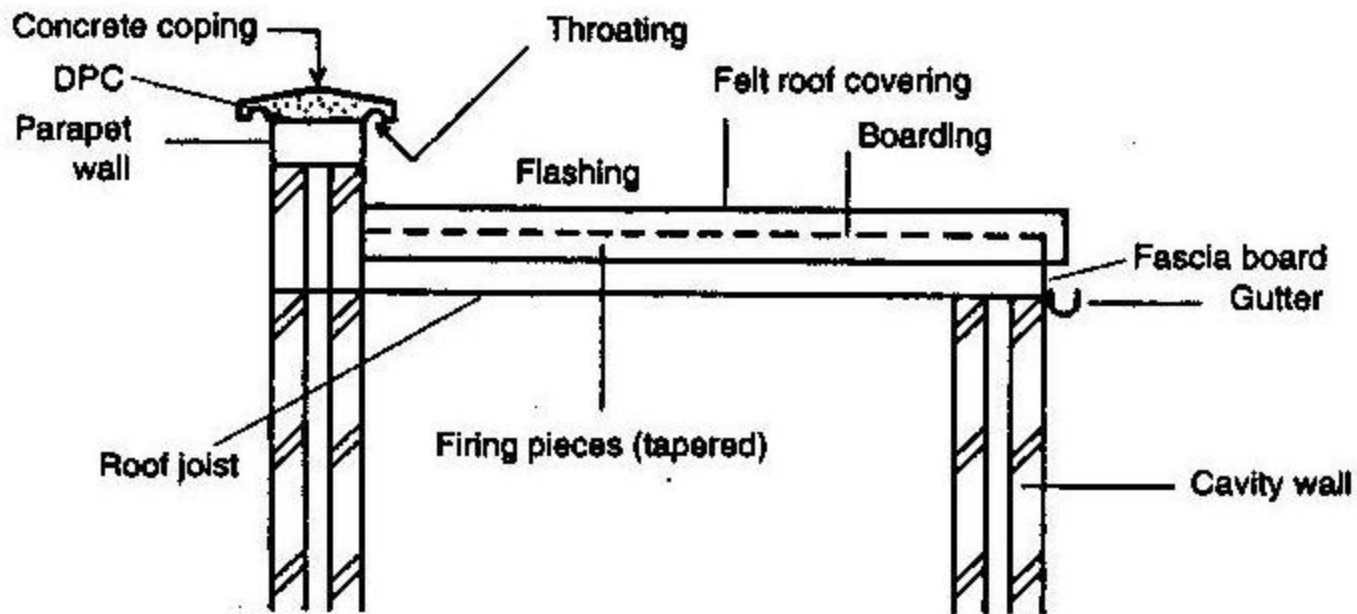


Figure 11.14 Flat roof

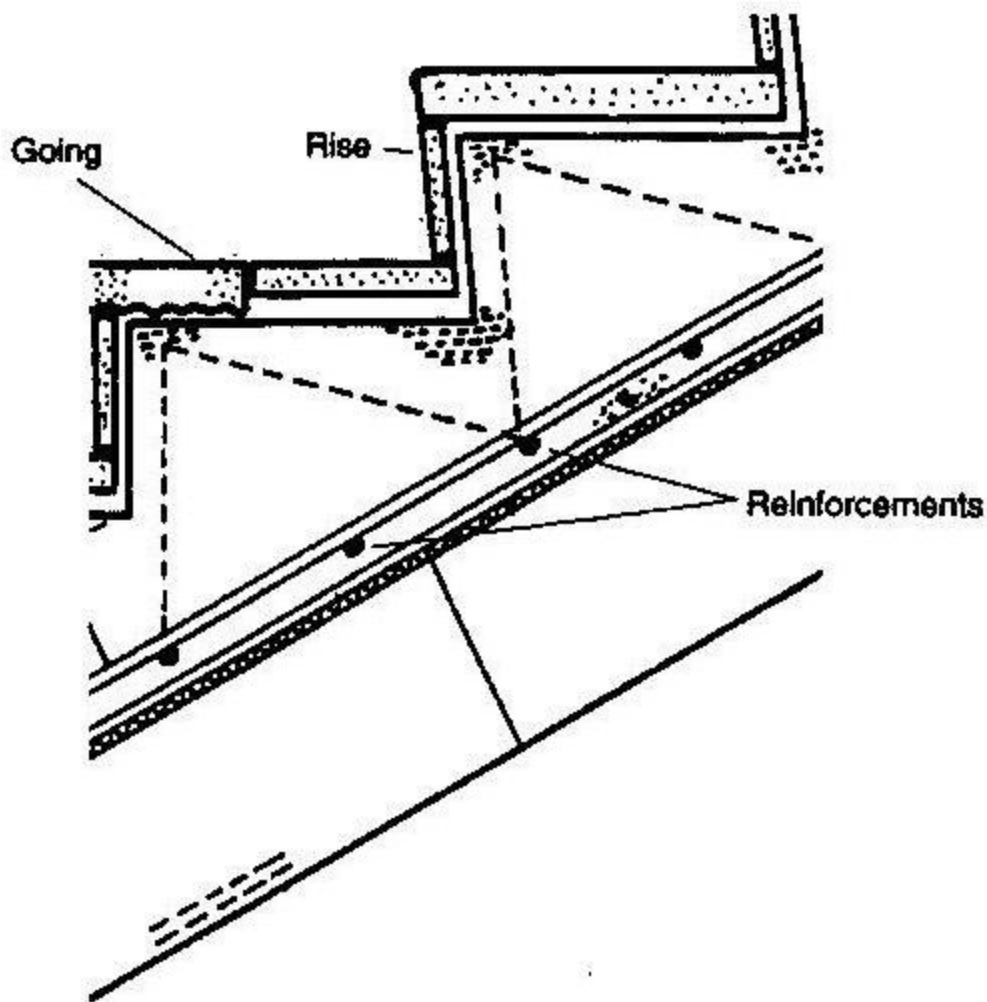


Figure 11.15 Staircase

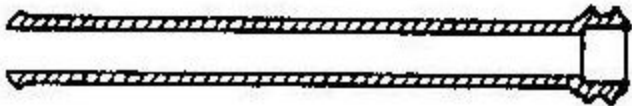


Figure 12.1 Cast iron pipe

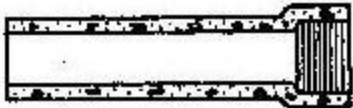


Figure 12.2 Stoneware pipe