11. Design of plumbing systems

A plumbing system is a long-term investment and should be so designed that it does not become outdated and need replacement while its major parts are still serviceable. This requires careful estimation of current and future demand so that the correct capacity can be specified.

The capacity and dimensions of component parts in a plumbing installation should be adequate to meet both immediate needs and anticipated future use. However, perfection in design is frequently compromised by cost, especially in poor and developing communities.

Good design of plumbing systems is an important step in ensuring that the installations are efficient, safe and affordable. It should take into account the special needs and limitations of developing countries and should also ensure that the installations are appropriate for the different situations they serve. An understanding of the technical requirements and regulatory restrictions is vital for the provision of good plumbing services. This chapter includes design recommendations for plumbing installations in single dwellings, multiple dwellings and multi-storey buildings. It deals with special issues related to industrial and other special purposes, hot water and other dual supply systems and storm water drainage. It includes guidelines on capacities of plumbing systems, plumbing materials and products, and the use of protective devices to prevent back-siphonage and backflow.

11.1 Drinking-water supply pipes and specifications

Table 11.1 lists the typical unit water demands for the design of plumbing systems for various classes of buildings.

In each case the actual values will depend on local conditions, but no water service pipe should be of less than 20 millimetres (0.75 inch) diameter and all water service pipes should be laid so as to avoid high points where air may become trapped. Usually the water service pipe between the public main and the curb cock (the water authority's main water shut-off valve) at the boundary of the property belongs to the water authority, which assumes responsibility for its future maintenance, and the remainder of the service pipe is the responsibility of the owner of the property (in many cases, the responsibility of the water authority is extended up to the meter).

TABLE 11.1 TYPICAL DEMANDS FOR VARIOUS USES

Class of building	Consumption per day (litres)
Dwelling houses and apartments, per occupant	40–120
Industrial and commercial premises, staff sanitary facilities, per staff member	10–30
Addition per staff member, if showers or baths are provided	10–15
Motels, per occupant plus staff:	
With communal baths	100–200
With private bathrooms for each bedroom	200–400
Luxury hotels in the tropics	400–600
Hospitals, per bed, including catering and laundry	350–500
Nurses' homes and medical quarters, per occupant	115–150
Schools, per occupant plus staff:	
Day schools	15–30
Boarding schools	100–200
Cinemas, theatres, per seat	8–15
Restaurants, per seat plus staff	75–100
Laundries, per kg dry laundry:	
Hand operated	30–40
Mechanized	60–90
Airports, bus or railway terminals, per passenger catered for plus staff	15–45
Addition per passenger catered for, if showers or baths are provided	10–15

Source: Taylor & Wood 1982 (p. 55).

The depth at which the service pipe should be laid will depend on climatic and other circumstances. In areas subject to frost, the depth specified should be sufficient to avoid damage from freezing, and a depth of 1 metre (3 feet) or even more may be required. However, a maximum depth should be specified to facilitate future maintenance and installation procedures and to enable the pipe to be tracked if required. In tropical areas it is desirable that the incoming water should be kept cool, and a depth of 0.5 metres (20 inches) may be suitable. Where the ground is under cultivation, a depth of 0.8 metres (30 inches) should provide adequate protection. Distance requirements from other services such as electric, telecommunications and gas pipes should be specified. Under no circumstances should a service pipe be permitted to pass through a sewer, access chamber or inspection chamber. Table 11.2 shows the minimum diameter of water pipes needed to supply various types of plumbing fixtures.

11.2 Drainpipes

Each separately occupied building should have its own drain connection terminating at the public sewer. Such drains should be of adequate size, and laid at a constant gradient that will permit their contents to discharge at a self-cleansing velocity. Drains carrying human wastes need to have a diameter of at least 100 millimetres (4 inches) for a single dwelling and at least 150 millimetres (6 inches) if more than one property is served. Where a number of plumbing systems have

TABLE 11.2 MINIMUM INTERNAL DIAMETER OF WATER PIPES TO PLUMBING FIXTURES

Plumbing fixture	Minimum internal diameter
Drinking fountain, washbasin, water closet with flush tank	10 mm (0.375 inch)
Bathtub, domestic dishwasher, hose connection, domestic water heater, shower, sink, urinal with flush tank	15 mm (0.5 inch)
Commercial sink, urinal with flush valve	20 mm (0.75 inch)
Water closet with flush valve	25 mm (1 inch)

Source: Taylor & Wood 1982 (p. 60).

a single connection to the sewer, the plumbing authority may require a combined drainage agreement or other documentation to ensure that disputes do not arise over the apportionment of maintenance responsibility.

Although internal and external drains are often referred to as "horizontal", they should never be laid level, but at a constant gradient that will ensure satisfactory drainage. A minimum velocity of 0.6 metres (2 feet) per second will prevent solids building up to block the pipe, and if the maximum velocity is limited to 3 metres (10 feet) per second this will prevent scouring and damage to the pipes. Table 11.3 shows the gradients at which these velocities are reached in pipes of various diameters and the approximate quantities that will be carried at such velocities.

TABLE 11.3 GRADIENTS TO PRODUCE MINIMUM AND MAXIMUM VELOCITIES IN DRAINS

Diameter of pipe		Minimum velocity 0.6 metres (2 feet) per second				Maximum velocity 3 metres (10 feet) per second			
		Grade		Carrying capacity per second		Grade		Carrying capacity per second	
mm	Inches	%	Litres	US gallons	UK gallons	%	Litres	US gallons	UK gallons
100	4	0.87	5	1.3	1.1	21.7	24	6.4	5.3
150	6	0.51	11	2.8	2.4	12.6	54	14.2	11.8
250	10	0.26	30	7.9	6.6	6.4	150	39.6	33.0
300	12	0.20	43	11.4	9.5	5.0	216	57.0	47.5

Source: Taylor & Wood 1982 (p. 59).

It may be necessary to use a pipe with a larger diameter if the relative levels of the building and the sewer are such that the appropriate gradient is inadequate to give a self-cleansing velocity for a particular size of pipe. However, a larger pipe will also have a tendency to lower velocity due to the fact that more of the water is in proximity to the frictional bed (contact surface between water and pipe). If the slope of the ground would cause the maximum velocity or gradient to be exceeded, the drain should be stepped, with the base of each vertical riser being adequately supported and the vertical section of the drain securely held in place. Such vertical sections can be more readily secured inside an access chamber.