Chapter

5.3

Drainage below ground

This chapter gives guidance on meeting the Technical Requirements for foul, surface water and groundwater drainage systems.

This chapter does not apply to the adoption of sewers under Section 104 agreement of the Water Industry Act 1991 or the Sewerage (Scotland) Act 1968. For information on standards required for adopted sewers, contact the local sewerage undertaker and other relevant authorities.

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Definitions for this chapter

For the purposes of this chapter, the following definitions apply:

Access point	Provision to access a sewer or drain for maintenance or inspection; includes any manhole, inspection chamber or rodding eye.
Curtilage	The area of land around a building, or group of buildings, which is for the private use of the occupants of the buildings.
Freeboard	The distance between the design water level and the top of a structure, provided as a precautionary safety measure against early system failure.
Gully	Assembly to receive water for discharge into a drainage system.
Infiltration system	A systems that is specifically designed to promote infiltration of surface water or treated effluent into the ground. There are many different types of drainage components which can be used to facilitate infiltration. Some of these include soakaways, infiltration trenches, infiltration basins and drainage fields for use in wastewater treatment.
Inspection chamber	Structure with a removable cover constructed on a drain or sewer that permits the introduction of cleaning and inspection equipment from surface level, but does not provide access for personnel.
Local authority	Includes an authority acting in any relevant capacity, such as a local planning authority (LPA), lead local flood authority (LLFA) or SuDS approval body (SAB).
Manhole	Structure with a removable cover constructed on a drain or sewer to permit entry by personnel.
Manhole top	Upper part of a manhole or inspection chamber consisting of a frame and cover and/or grating.
Private drain	Used for the drainage of one building or any buildings or yards appurtenant to buildings within the same curtilage.
Public sewer	A sewer for the time being vested in a water company in its capacity as sewerage undertaker.
Rising main	A sewer through which foul sewage and/or surface water is pumped.
Satisfactory outfall or effective discharge point	Point of discharge which has been specifically designed to discharge the foul sewage or surface water and for which there is a legal right to discharge. This can be another sewer or a watercourse (if there is a legal right to discharge) or an area of land or another infiltration drainage component.
Septic tank	A form of wastewater treatment plant; refers to both traditional in-situ constructed septic tanks as well as prefabricated septic tanks (or small wastewater treatment systems for up to 50 PT) conforming to BS EN 12566.

5.3.1 Compliance

Also see: Chapter 2.1

Drainage systems shall comply with the Technical Requirements.

Below ground drainage that complies with the guidance in this chapter will generally be acceptable.

All drainage schemes require the approval of the building control authority. Local sewerage undertakers may impose additional requirements and restrictions. Both should be consulted early, especially where the drainage system is to be adopted under a Section 104 agreement of the Water Industry Act 1991 or Sewerage (Scotland) Act 1968. The system may need to be inspected and tested by the sewerage undertaker, as well as by the local authority, building control authority and NHBC.

Satisfactory outfall disposal is essential where a septic tank or equivalent sewage treatment plant is installed. In England and Wales, Environment Agency consent may be required to discharge effluent from a septic tank or equivalent sewage treatment plant. In Northern Ireland, the Northern Ireland Environment Agency (NIEA) should approve proposals; in Scotland, the local authority and, where appropriate, the river purification authority should approve proposals.

Ground conditions may preclude the use of septic tanks or equivalent sewage treatment plant in some locations. In all cases, NHBC will require evidence of a satisfactory percolation test where an infiltration drainage system is being installed.

For surface water discharge into a watercourse, the permission of the Environment Agency is required in England and Wales. A ‘consent to discharge’ is required from the NIEA. In Scotland, the local authority and, where appropriate, the river purification authorities should be consulted.

In all cases:

- relevant local authorities should be consulted and appropriate permissions sought before sitework begins
- NHBC will require evidence of a satisfactory percolation test where a septic tank or equivalent sewage treatment plant is being installed.

Table 1: Guide to relevant authority

	Septic tank discharge	Surface water discharge into a watercourse
England and Wales	Environment Agency DEFRA	
Northern Ireland	Northern Ireland Environment Agency	
Scotland	Local authority River purification authority	Local authority River purification authority Scottish Environmental Protection Agency

5.3.2 Provision of information

Designs and specifications shall be produced in a clearly understandable format, include all relevant information and be distributed to all appropriate personnel.

Design and specification information should be issued to site supervisors, relevant specialist subcontractors and suppliers, and include the following information:

- proposed drain layout
- invert levels and locations of existing sewers
- junctions
- ground floor levels of homes
- external finished levels
- inspection and access points
- method of disposal of both foul and surface water
- position of any septic tank or cesspool in relation to adjacent buildings
- results of percolation tests where treated effluent disposal is through field drains or surface water through soakaways
- length of field drains and their layout (including details of trench width as this is critical to the functioning of the system)
- depth of field drains
- details of drains or sewers intended for adoption
- details of soakaways (including size or volume and surrounding details).

5.3.3 Preliminary work

Drainage systems shall be checked on site to ensure that the design can be achieved.

Check that the following are as specified in the design:

- invert levels and locations of existing sewers
- ground floor levels of homes
- external finished levels.

Percolation tests should be verified where treated effluent disposal is through field drains. The length of any field drains specified in the design should be accommodated within the site boundaries.

5.3.4 Foul and surface water disposal

Also see: BS EN 752, Clause 5.3.11 and BRE Digest 365

Drainage systems shall be designed in accordance with relevant codes and standards to convey foul effluents and surface water satisfactorily to an appropriate outfall. Issues to be taken into account include:

1) **connections to sewers**
2) **connections to surface water disposal systems**
3) **rights of connection to disposal systems**
4) **compatibility with other systems**
5) **capacity of private sewers**
6) **treatment plants for more than one home.**

5.3.4.1 Connections to sewers

Connections to public sewers require the agreement of the responsible authority, which should be consulted regarding the type and position of the connection.

Connections to private sewers require the agreement of the owners of the sewer. This should be obtained as part of the design process. Where the private sewer subsequently discharges into a public sewer, the local sewerage undertaker should be notified of the proposal.

5.3.4.2 Connections to surface water disposal systems

Surface water drainage is generally required to be separated from foul water drainage. Where permitted, surface water may be discharged into the main public surface water drains or directly into natural watercourses, ponds or soakaways, as appropriate. Surface water should not discharge to:

- septic tanks
- cesspools
- separate foul sewers.

For large or complicated homes, the volume of surface water to be disposed should be calculated in accordance with BS EN 12056-3.

5.3.4.3 Rights of connection to disposal systems

A legal right must exist when connecting drains to an outfall.

5.3.4.4 Compatibility with other systems

The drainage system should be compatible with the main sewerage system:

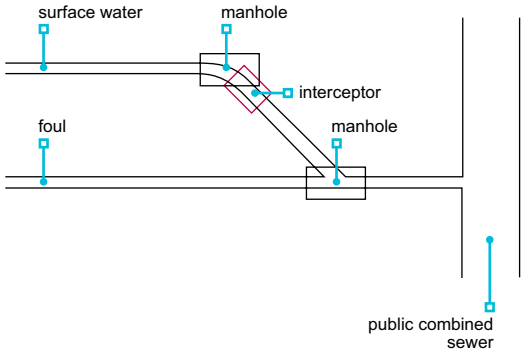
- with separate systems for foul water and surface water
- with separate systems where foul water is connected to the main sewer, while surface water disposal is by soakaways or other suitable means, or
- as a combined system.

Where the sewerage undertaker permits surface water drains to be connected to a foul water system:

- an interceptor should be installed on the surface water side of the foul sewer junction, or
- trapped gullies should be used.

Where groundwater drains are connected to surface water drains, there should be a silt trap on the groundwater side of the junction.

Figure 1: Interceptor requirement when connecting surface water drain into a combined sewer



5.3.4.5 Capacity of private sewers

Private drainage systems should be:

- in accordance with BS EN 752
- sufficient to cope with the intended capacity.

Where an existing private drainage system is to be extended, or where the capacity is to be increased, sufficient investigation, measurement and calculation should be undertaken to ensure that all parts of the private system are of adequate capacity.

5.3.4.6 Treatment plants for more than one home

Small sewage treatment works for more than one home should be designed in accordance with BS EN 12566.

Discharge from the waste water treatment plant should be:

- sited at least 10m away from watercourses and homes
- designed by a suitably qualified engineer.

5.3.5 Drainage system performance

Also see: Chapters 4.1, 8.1, BRE Report 211 and BRE Report 212

Drainage shall be suitably located and prevent health hazards. Issues to be taken into account include:

1) **ventilation of drainage systems**
2) **prevention of gases entering the home**
3) **siting of septic tanks and cesspools**
4) **pumped systems.**

5.3.5.1 Ventilation of drainage systems

Ventilation of drains is normally achieved by ventilating discharge stacks.

Air admittance valves which comply with Technical Requirement R3 may be used in some homes to prevent trap seal siphonage. An open vent is generally required at the head of common drainage systems, and where the discharge pipe is the only vent for a septic tank or cesspool.

5.3.5.2 Prevention of gases entering the home

Where special precautions are necessary (eg sealing drains where they enter the building) to reduce the entry of gases such as radon or landfill gas, such precautions should be acceptable to NHBC.

5.3.5.3 Siting of septic tanks and cesspools

Septic tanks and cesspools should be:

- a minimum of 7m from homes
- a maximum of 30m from vehicular access to permit emptying.

In Scotland, a minimum distance of 5m from homes and boundaries is acceptable for septic tanks.

5.3.5.4 Pumped systems

Where a gravity system is not possible, pumped systems may have to be used and should be designed in accordance with BS EN 752 and BS 6297. The installation should include:

- a holding tank of sufficient volume to contain 24 hours of domestic effluent based on 120L/150L per head per day
- a suitable warning system providing visual and/or audible signals to indicate malfunction
- suitable equipment housing.

5.3.6 Groundwater drainage

Groundwater drainage shall convey excess groundwater to a suitable outfall. Issues to be taken into account include:

1) layout of pipes
2) pipe construction.

5.3.6.1 Layout of pipes

Where groundwater drainage is required, depending on the site contours and ground conditions, it may be designed as:

- a natural system
- a herringbone system
- a grid system
- a fan-shaped system
- a moat system.

5.3.6.2 Pipe construction

Pipe perforations should be holes or slots to suit the nature of the ground.

Groundwater drain systems connected to foul, surface water or combined drains should discharge into the drain through a catchpit. Where suitable, groundwater drainage may discharge into a soakaway, preferably through a catchpit or into a watercourse.

5.3.7 Design to avoid damage and blockages

Also see: Chapter 4.2, BS EN 476, BS EN 13598-1 and 2 and SfA-7

Drainage systems shall minimise the risk of damage and blockage. Issues to be taken into account include:

1) ground stability
2) pipe runs
3) pipe sizes
4) gradients
5) access and connections
6) drainage covers and gully grids
7) groundwater
8) flooding.

5.3.7.1 Ground stability

Proper allowance should be made for ground movement.

Pipes should have flexible joints and additional precautions taken to prevent leakage where required. Where ground movement could be significant, for example in made-up ground or clay soils, the following issues should be taken into account:

- the use of flexible pipes and flexible joints
- design gradients that are steeper than the minimum requirements for flow rate and pipe size
- a support system designed by an engineer in accordance with Technical Requirement R5
- conditions where ground movement is likely to adversely affect the drain.

In non-uniform or saturated soils where movement at the trench bottom can be expected, soft spots should be removed and replaced with suitable material. Immediately after excavation, the protective blinding should be placed in the trench bottom.

5.3.7.2 Pipe runs

Pipe runs should be designed to maintain a self-cleansing velocity (0.7m/s). They should be as straight as practicable with minimal changes of direction. Bends should only occur in, or next to, inspection chambers and manhole covers. Curves should be slight so that blocked pipes can be cleared.

5.3.7.3 Pipe sizes

Pipe sizes should be designed for the maximum peak load in accordance with BS EN 752.

Groundwater drains and soakaways should be designed with sufficient capacity for normal weather conditions.

5.3.7.4 Gradients

Design gradients should:

- be as even as practicable
- where flows are less than 1.0L/second, gradients for 100mm diameter pipes should not be flatter than 1:40
- where peak flows exceed 1.0L/second, the gradients in Table 2 may be used.

Table 2: Minimum gradients

Pipe diameter (mm)	Minimum gradient
100	1:80
150	1:150

Where peak flows are greater than 1.0L/second, 100mm pipes should serve a minimum of one WC and 150mm pipes should serve a minimum of five.

5.3.7.5 Access and connections

To ensure that every length of drain can be rodded, the design should include appropriately located access points, such as:

- rodding points
- access fittings
- inspection chambers
- manholes.

Figure 2: Access fitting

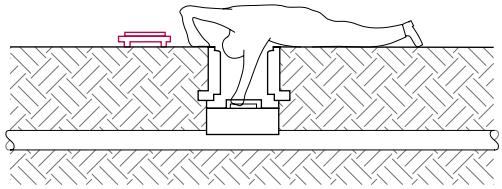


Figure 3: Inspection chamber

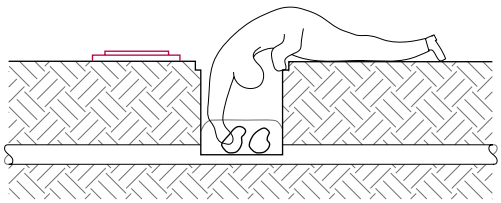
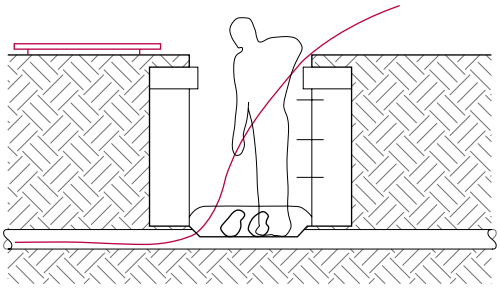


Figure 4: Manhole



All access points should be located as shown in the design information and should be accessible for rodding and cleaning.

Inspection chambers and manholes should be of sufficient size for the depth of invert:

- not cross boundaries or kerb lines
- the invert depth for the fitting or chamber should not exceeded those given in Table 3.

Table 3: Minimum dimensions for access fittings and inspection chambers

Type		Depth to invert from cover level (m)	Minimum internal sizes		Clear openings	
			Length x width (mm x mm)	Circular (mm)	Length x width (mm x mm)	Circular (mm)
Rodding point			As drain but min. 100			Same size as pipework
Small access fitting	150 dia. 150 x 100	0.6 or less, except where situated in a chamber	150 x 100	150	150 x 100	Same size as access fitting
Large access fitting	225 x 100		225 x 100	225	225 x 100	Same size as access fitting
Shallow inspection chamber		0.6 or less 1.2 or less	225 x 100 450 x 450	190(1) 300(3)	– Min. 430 x 430	190 310
Deep inspection chamber		Greater than 1.2	450 x 450	300(4) - 450	Max. 300 x 300(2)	Access restricted to max. 350(2)

Notes
1. Drains up to 150mm.
2. A larger cover may be used in conjunction with restricted access. The size is restricted for health and safety reasons to deter entry.
3. Minimum 300mm diameter inspection chamber complying with BS EN 13598-1 or -2.
4. Minimum 300mm diameter inspection chamber complying with BS EN 13598-2 may be used up to a depth of 2m.

Table 4: Minimum dimension for manholes

Type	Size of largest pipe (DN) (mm)	Minimum internal dimensions (1)		Min. clear opening size (1)	
		Rectangular length and width (mm)	Circular diameter (mm)	Rectangular length and width (mm)	Circular diameter (mm)
Manhole up to 1.5m deep to soffit	Equal to or less than 150 225 300 Greater than 300	750 x 675(7) 1,200 x 675 1,200 x 750 1,800 x (DN+450)	1,000(7) 1,200 1,200 The larger of 1,800 or (DN+450)	750 x 675(2) 1,200 x 675(2)	NA(3)
Manhole greater than 1.5m deep to soffit	Equal to or less than 225 300 375-450 Greater than 450	1,200 x 1,000 1,200 x 1,075 1,350 x 1,225 1,800 x (DN+775)	1,200 1,200 1,350 The larger of 1,800 or (DN+775)	600 x 600	600
Manhole shaft(4) greater than 3.0m deep to soffit pipe	Steps(5)	1,050 x 800	1,050	600 x 600	600
	Winch(6)	900 x 800	900	600 x 600	600
	Ladder(5)	1,200 x 800	1,200		

Notes
1. Larger sizes may be required for manholes on bends or where there are junctions.
2. May be reduced to 600mm x 600mm where required by highway loading restrictions and subject to a safe system of work being specified.
3. Not applicable due to working space needed.
4. Minimum height of chamber in shafted manhole 2m from benching to underside of reducing slab.
5. Minimum clear space between ladder or steps and the opposite face of the shaft should be approximately 900mm.
6. Winch only; no steps or ladders, permanent or removable.
7. The minimum size of any manhole serving a sewer ie, any drain serving more than one home, should be 1,200mm x 675mm rectangular or 1,200mm diameter.
8. Tables 3 and 4 have been reproduced from Tables 11 and 12 of Approved Document H by permission of HMSO.

Inspection chambers and manholes may be one of the following types:

- open, half-round section channel with suitable benching
- closed access, where covers have to be removed to gain access to the pipe.

Side branches to inspection chambers and manholes should discharge into the main channel no higher than half pipe level. Connections should be made obliquely in the direction of flow.

Figure 5: Acceptable connection — rectangular manhole

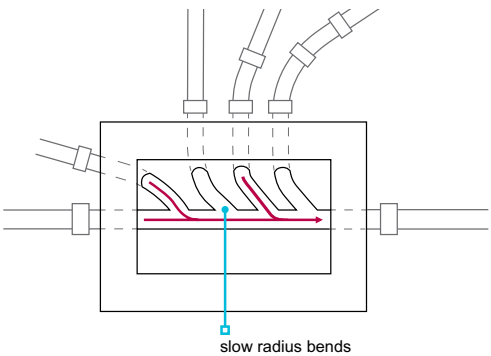
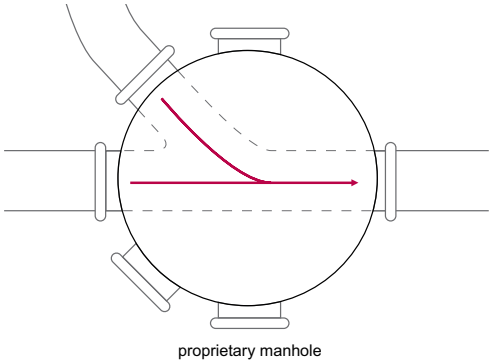


Figure 6: Acceptable connection — proprietary manhole

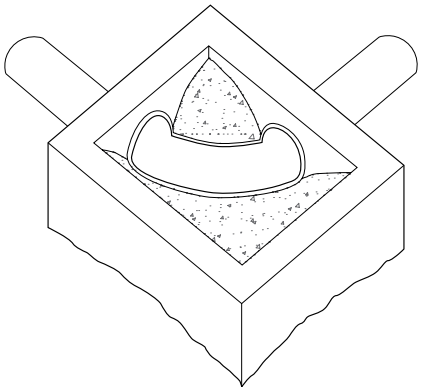


Traditional construction

The minimum specification for traditional manholes and inspection chambers is as follows:

Base	Minimum 100mm concrete
Walls	Brick, blockwork or concrete should be appropriate for the ground conditions 100mm minimum thickness is suitable for depths up to 0.9m where no vehicular traffic loads are encountered and there is no groundwater pressure Elsewhere, 200mm minimum thickness should be provided
Rendering	Where required, rendering should be applied to the external faces of the wall
Benching	Benching should be steel trowelled to provide: • a smooth finish • rounded corners • a fall of not less than 1:12

Figure 7: Traditional benching



Clay bricks for manholes should comply with BS EN 771 and:

- be of low active soluble salt content
- have a minimum compressive strength of 48N/mm^2.

Engineering bricks are also suitable.

Concrete bricks for manholes should:

- comply with BS EN 771
- have a minimum crushing strength of 48N/mm^2 with a minimum cement content of 350kg/m^3 for foul drainage.

Calcium silicate bricks should comprise strength class 20 or above for foul drainage situations.

Proprietary systems

Proprietary systems should be:

- in accordance with Technical Requirement R3
- installed in accordance with manufacturers' instructions.

Proprietary manholes should not be used at a depth greater than the manufacturer's instructions.

Adaptors, couplers and sealing rings should be:

- installed correctly and in accordance with the manufacturer's instructions
- treated using the lubricants and solvents specified.

5.3.7.6 Drainage covers and gully grids

Manhole covers and gully grids should be of the correct type for the proposed location in accordance with Tables 5 and 5a.

Manhole covers used within buildings should be airtight and mechanically secured. Covers used for septic tanks, cesspits and settlement tanks should be lockable.

Manholes should be constructed or installed at the correct level so that the covers will align with the adjacent ground.
Gullies should be adequately:

- bedded
- square and kerbed.
- set level

Table 5: Type of covering and grid required for inspection and manhole covers and frames

Group 1	Areas which can only be used by pedestrians and cyclists
Group 2	Footways, pedestrian areas and comparable areas, car parks or car parking decks
Group 3	For gully tops installed in the area of kerbside channels of roads which when measured from the kerb edge, extend a maximum of 0.5m into the carriageway and a maximum of 0.2m into the footway
Group 4	Carriageways of roads, including pedestrian streets, hard shoulders and parking areas, and suitable for all types of road vehicles

Proprietary items, eg covers to plastic manholes, should be in accordance with manufacturers' recommendations.

Table 5a: Gully grids in carriageways

Grade B	For use in carriageways of roads with cars and slow-moving normal commercial vehicles
Grade A class 2	For use in carriageways of roads
Grade A class 1	For use in carriageways of roads (gully grids of permanent non-rock design)

5.3.7.7 Groundwater

Foul and surface water drainage systems should prevent the ingress of groundwater.

5.3.7.8 Flooding

Where there is a risk of flooding, the advice of the relevant river authority should be followed.

5.3.8 Durability

Also see: Chapters 3.1 and 6.1

Drainage systems shall be adequately durable and protected against damage. Issues to be taken into account include:

1) **loads from foundations**
2) **bedding of pipes**
3) **loads from overlying fill and traffic**
4) **chemicals in ground and groundwater.**

5.3.8.1 Loads from foundations

Drains should be located so that foundation loads are not transmitted to pipes. Where drainage trenches are near foundations:

- foundation bottoms should be lower than adjacent trenches, or
- the drain should be re-routed to increase separation.

Where the bottom of a drainage trench is below foundation level, the trench should be filled with concrete to a suitable level.

Figure 8: Pipe protection in close proximity to foundation

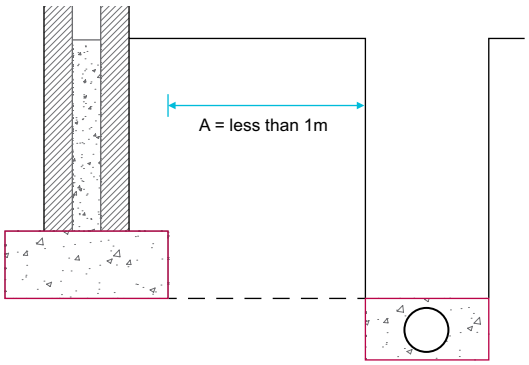
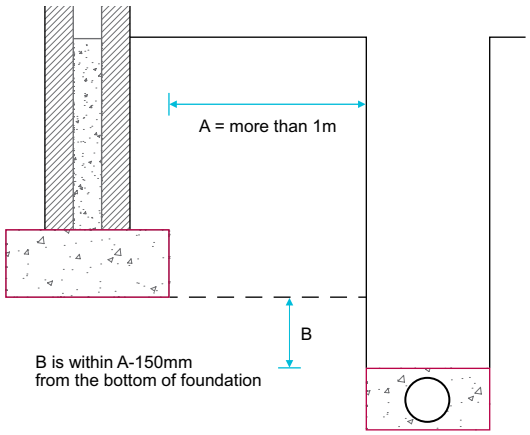


Figure 9: Pipe protection within influence zone of the foundation



5.3.8.2 Bedding of pipes

Bedding should be in accordance with Clause 5.3.15.

5.3.8.3 Loads from overlying fill and traffic

Special protection may be required where pipes are near the ground surface or where they could be damaged by the weight of backfill or traffic load from above.

For flexible pipes, and where greater safety is needed, the bedding class and grading of backfill should comply with BS EN 13242, BS EN 1610 and BS EN 752.

When using proprietary systems assessed in accordance with Technical Requirement R3, pipes should be supported accordingly.

5.3.8.4 Chemicals in ground and groundwater

Where the ground or groundwater contains sulfates, concrete and masonry work may require special precautions.

5.3.9 Septic tanks and cesspools

Septic tanks and cesspools shall be correctly installed and be suitable for their intended use. Issues to be taken into account include:

1) capacity
2) access and ventilation
3) permeability of septic tanks and cesspools
4) connections to septic tanks and cesspools.

A septic tank is a form of treatment plant and requires a suitable outfall for treated effluent discharge, which is agreed with the relevant authority.

A cesspool is a tank which stores effluent and has to be emptied periodically.

5.3.9.1 Capacity

The capacity of the septic tank should be based on the number of people it will serve, using the formula: C = 180P + 2,000.

C = Capacity of tank in litres. Minimum 2,700L.

P = Design population/potential occupancy. Minimum four occupants.

Cesspools are required to be at least 18m^3 capacity per two users (plus another 6.8m^3 per each extra user). A 45-day holding capacity calculated at 150 litres/head/day should be provided.

5.3.9.2 Access and ventilation

Septic tanks and cesspools should:

- be covered and ventilated
- be provided with access points for inspection, emptying, de-sludging and cleaning
- have the access points with lockable covers and no dimension less than 600mm.

The inlet and outlet of a septic tank should be provided with access for inspection. The inlet of a cesspool should be provided with access for inspection. Cesspools should have no openings except the inlet, the vent and the inspection access.

5.3.9.3 Permeability of septic tanks and cesspools

Septic tanks and cesspools should be impermeable to their contents and to subsoil water. They should be constructed of brickwork, concrete, glass reinforced concrete, glass reinforced plastics or steel.

Brickwork should be of engineering bricks, laid in cement mortar at least 220mm thick. In-situ concrete should be at least 150mm thick.

5.3.9.4 Connections to septic tanks and cesspools

The entry flow velocity should be restricted to reduce disturbance in the tank. Where the drain into the septic tank is less than 150mm in diameter, it should have a gradient no steeper than 1:50 for at least 12m.

Rodding and cleaning facilities should be provided at the connection with the tank.

5.3.10 Septic tank outputs

Also see: BS 6297

Septic tanks shall have suitable drainage connections. Issues to be taken into account include:

1) outfall
2) flow velocity
3) soakaways for septic tanks
4) field drains
5) underdrains.

5.3.10.1 Outfall

The designer should ensure at an early stage that consent for discharge will be given, or select an alternative method of drainage. Certain locations and ground conditions may preclude the use of proprietary septic tanks. Septic tank sewage systems should have:

- satisfactory outfall disposal
- placement that accounts for topography and ensures that water is drained away from the building.

Where a septic tank drainage system is to be installed, NHBC requires:

- evidence of a satisfactory percolation test
- copies of relevant consents and approvals before work commences.

5.3.10.2 Flow velocity

A dip pipe should be provided with:

- the top limb rising above scum level,
- the bottom limb extending about 450mm below top water level.

5.3.10.3 Soakaways for septic tanks

Soakaways in porous subsoils

A soakaway may be used where the outfall from a proprietary septic tank is to discharge to a porous subsoil at a level above that of the winter water table. Soakaway constructions generally consist of an excavation filled with brick bats or other large pieces of inert material, or unfilled but lined, eg with dry laid brickwork or precast concrete (porous or perforated) rings, from which the effluent may percolate into the surrounding ground. Proprietary septic tanks should be assessed in accordance with Technical Requirement R3.

Soakaways which are not filled should be covered by a slab incorporating an inspection cover.

The size of the soakaway should be determined as described in this chapter and the area of the bottom of the soakaway should equal the area of trench bottom in Chart 1.

Where the porous strata is overlaid by less permeable subsoil, a borehole may be permitted by the appropriate authority on obtaining a discharge consent.

Where soakaways are to be used, the use of a tertiary treatment unit may be required to minimise the amount of suspended solids in the treated wastewater, and the use of a grease trap to part cleanse kitchen wastewater, upstream of a packaged treatment plant, may also be necessary to minimise the risk of fat clogging up the soakaway system.

Where a geotextile wrapped cellular soakaway is the desired outfall for a single unit treatment plant or a proprietary septic tank, it should be designed for the discharge from the treatment plant to flow via the silt trap chamber before entering the soakaway. The chamber should be regularly maintained (together with the treatment plant) to ensure suspended particles discharged into the soakaway is minimised.

Soakaways in less porous subsoils

In less porous subsoils, a sub-surface irrigation system may be used, which should be designed:

- using approved means to determine the percolation rate
- according to the area of sub-surface drainage from which the length of land drain can be found, determined by the following procedure.

Table 6: Percolation test procedure for septic tanks

Step 1	Excavate a hole 300mm square and 250mm deep below the proposed invert level of the land drain
Step 2	Fill with water to depth of 250mm. As an aid, mark a stick 250mm from one end, place in the hole and fill to the mark. Allow the water to drain away overnight
Step 3	Refill to a depth of at least 250mm and note the time taken (in seconds) to drain away completely
Step 4	Repeat the exercise two more times and calculate the average of the three results, as follows: percolation value (s) = $\frac{\text{time to drain away (seconds)}}{\text{depth of water (mm)}}$

The results of the percolation test should be used in accordance with Table 6a to determine a suitable method of drainage.

Table 6a: Suitable methods of drainage

Percolation value (s)	Suitability for less porous subsoils
Up to 100	Chart 1 to determine the field drain trench area Chart 2 to determine the pipe length to provide this area
100 to 140	As above, but underdrains are also necessary
Over 140	The soil is unsuitable for field drains

Table 7: Capacity based on potential occupancy

Number of persons/bed spaces	Minimum capacity (litres)
<4	2,700
4	2,720
5	2,900
6	3,080
7	3,260
8	3,440
9	3,620
10	3,800

Chart 1: Field drains trench area

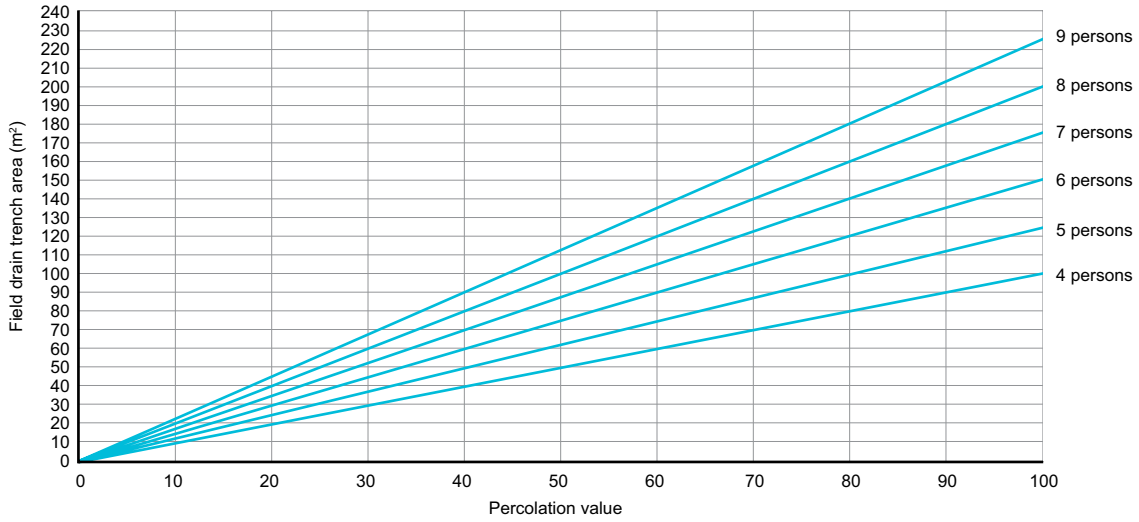
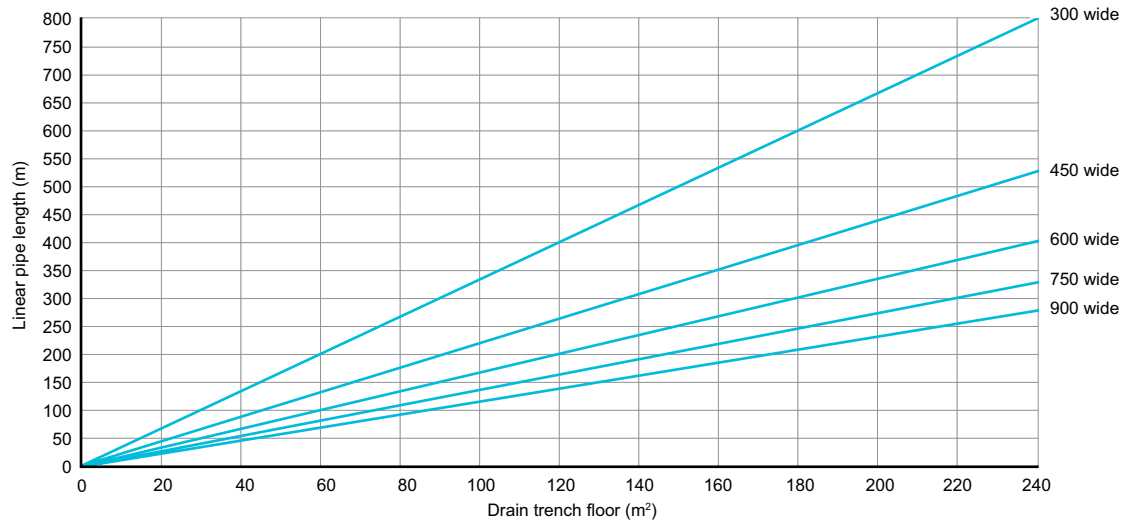


Chart 2: Field pipe length



5.3.10.4 Field drains

Field drains should be:

- sited according to topography, ensuring that water is drained away from the building
- formed with perforated pipe, laid at least 500mm below the surface
- laid in trenches with a uniform gradient less than 1:200, with undisturbed ground 2m wide between trenches and at least 8m from any building and 10m from any watercourse
- laid on a 150mm bed of clinker, clean gravel or broken stone (20mm–50mm grade) and trenches filled to a level 50mm above the pipe and covered with strips of plastic material to prevent entry of silt
- backfilled with as-dug material.

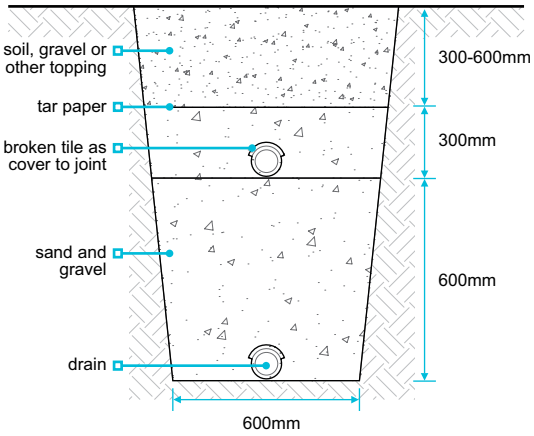
Where the level of the water table is expected to rise in the winter months to within 1m of the field drain invert, it is not acceptable to use subsurface irrigation.

5.3.10.5 Underdrains

Where underdrains are necessary, drainage trenches should be constructed a minimum of 600mm deeper than the pipe level specified in the design.

The lower part of the drainage trenches should be filled with pea gravel. A second system of drainage pipes should be laid on the bottom of the trenches to convey surplus drainage to an outfall in a surface ditch or watercourse.

Figure 10: Cross section of a typical underdrain



5.3.11 Surface water soakaways

Also see: BRE Digest 365

Soakaway drainage shall be sited and constructed to provide adequate short-term storage for surface water and adequate percolation into the surrounding ground. Issues to be taken into account include:

1) soakaway location

2) soakaway design.

5.3.11.1 Soakaway location

Soakaways should be:

- built on land lower than, or sloping away from, buildings
- sited at least 5m from the foundations of a building
- sited to take account of topography, ensuring that water is drained away from the building
- in soil of low permeability, only provided where no alternative system is available.

5.3.11.2 Soakaway design

NHBC will require a percolation test for a soakaway, especially where there is:

- doubt about the ground
- a large quantity of run-off into the soakaway which may swamp the ground.

Where the ground is free draining and granular, a test may not be necessary.

In soil, chalk and fill material subject to modification or instability, the advice of a specialist geotechnologist should be sought regarding the siting and suitability of soakaways.

Large soakaways

Large soakaways consist of a pit lined with dry jointed or honeycomb brickwork.

Alternatively, precast perforated concrete rings or segments may be laid dry and surrounded with granular material.

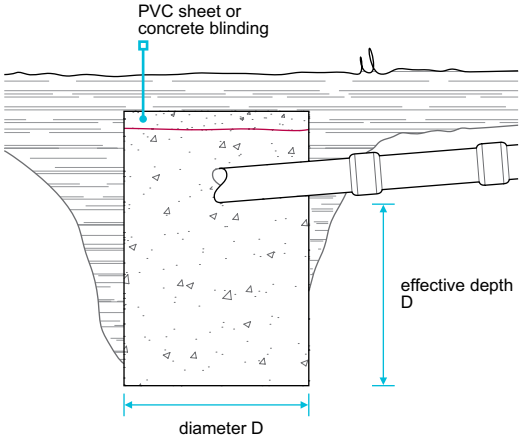
Large soakaways should be designed in accordance with BRE Digest 365, and the volume calculated to ensure suitable capacity, including checking the appropriate time to empty half the storage volume.

Small soakaways

Small soakaways are holes filled with granular material, eg broken brick, crushed rock or gravel, with particle size 10mm to 150mm.

PVC sheet or concrete blinding should be laid over the fill to prevent topsoil being washed down into the soakaway.

Figure 11: Typical cross section of a small surface water soakaway



Percolation test procedure for small surface water soakaway

The rate at which water will disperse into the ground depends on the permeability of the ground, which varies with soil type. The percolation test provides an assessment of how the ground drains.

The following test procedure and design approach may be adopted where the soakaway is for a single dwelling development with a total drained area of less than 100m^2.

As the test hole can be used as part of a soakaway, it should be:

- dug in a place that could be used as a soakaway
- at least 5m from the foundations of a building
- to the same depth as the proposed drain.

Table 8: Percolation test procedure for small surface water soakaways

Step 1	Bore a hole 150mm in diameter with an auger, to a depth of one metre
Step 2	Fill with water to depth of 300mm. As an aid, mark a stick 300mm from one end, place in the hole and fill up to the mark. It takes approximately 5.5 litres to fill a volume of this size
Step 3	Observe the time taken in minutes for the water to soak away
Step 4	Where possible, the test should be repeated and the average time used
Step 5	A second group of tests are carried out after the hole has been bored out to a depth of two metres, still using a 300mm depth of water
Step 6	Where the soil appears to become more permeable with depth, it may be useful to deepen and retest the bore in one-metre stages

Design of small soakaway

The relationship between the diameter or effective depth required for a soakaway to suit a given collection area, eg roof or paved surface, and the average time (T) resulting from the test, is shown in Chart 3.

The diameter and effective depth below invert level are assumed to be the same dimension (D) — see Figure 11.

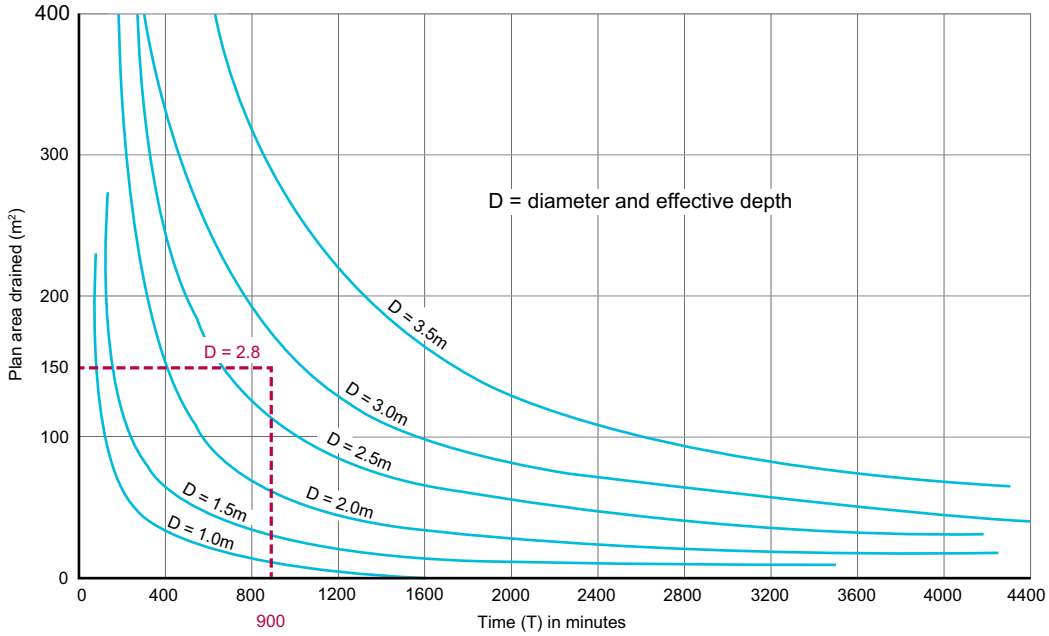
Example

Test time (T) = 900 minutes

Plan area to drain = 150m^2

Chart 3: Graph for sizing small soakaways using 150mm diameter test hole

From the graph below, the diameter and effective depth of the soakaway (D) are both 2.8m.



Where the ground is of low permeability; dig separate soakaways to drain smaller but distinct parts, for example:

- one side of a roof to one soakaway
- the other side to a second soakaway
- the driveway or yard to a third soakaway.

Where the permeability of the ground increases with depth, tests in the deepened trial holes will give shorter percolation times. It may be more cost effective to build a smaller soakaway at a greater depth below the surface.

5.3.12 Component requirements

Drainage systems shall be constructed with materials that ensure satisfactory service over the life of the system.

Components in accordance with the following standards will generally be acceptable.

Table 9: British Standards and relevant codes of practice

BS 65	Specification for vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely with surface water pipes and fittings
BS 437	Specification for cast iron drain pipes, fittings and their joints for socketed and socketless systems
BS 4660	Thermoplastics ancillary fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage — specification
BS 4962	Specification for plastics pipes and fittings for use as subsoil field drains
BS 5911	Precast concrete pipes, fittings and ancillary products
BS EN 124	Gully tops and manhole tops for vehicular and pedestrian areas
BS EN 295	Vitrified clay pipe systems for drains and sewers
BS EN 476	General requirements for components used in drains and sewers
BS EN 588	Fibre-cement pipes for sewers and drains
BS EN 877	Cast iron pipes and fittings, their joints and accessories for the evacuation of water from buildings. Requirements, test methods and quality assurance
BS EN 1401-1	Plastics piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U) — Specifications for pipes, fittings and the system
BS EN 1916	Concrete pipes and fittings, unreinforced, steel fibre and reinforced
BS EN 12566-1	Small wastewater treatment systems for up to 50 PT — Prefabricated septic tanks
BS EN 13101	Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity
BS EN 13476	Plastic piping systems for non-pressure underground drainage and sewerage. Structured wall piping systems of unplasticized poly (vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE). Parts 1, 2 and 3
BS EN 13598-1	Plastics piping systems for non-pressure underground drainage and sewerage. Unplasticized poly (vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE). Specifications for ancillary fittings and shallow chambers
BS EN 13598-2	Plastics piping systems for non-pressure underground drainage and sewerage. Unplasticized poly (vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) — Specifications for manholes and inspection chambers

5.3.13 Excavation

Excavations shall ensure that the invert levels and gradients required by the design are achieved. Issues to be taken into account include:

1) **setting out dimensions**
2) **depth of trenches**
3) **width of trenches.**

5.3.13.1 Setting out dimensions

When setting out:

- discrepancies in dimensions, and ground conditions which require design modification, should be reported to the designer
- drain runs and depths should be set out from benchmarks previously checked and verified
- resulting variations should be recorded and distributed to all concerned.

5.3.13.2 Depth of trenches

Excavate to the depths specified in the design.

Where any trench is excavated lower than the designed bottom level, it should be refilled to the designed level.
Fill material should be:

- granular material, or
- concrete mix GEN1 or ST ½ (not for field drains).

Hard spots should be undercut and removed so that local stress points under pipes are avoided. Soft spots should be filled with suitable well-compacted material.

5.3.13.3 Width of trenches

Trenches should be as narrow as possible within working limits and allow a minimum 150mm working space on each side of the pipe.

5.3.14 Protection of pipework

Also see: Chapters 4.3 and 5.1

Drainage systems shall have pipework adequately protected against damage. Issues to be taken into account include:

1) **pipes passing through substructure walls**
2) **pipework under finishes**
3) **movement joints.**

5.3.14.1 Pipes passing through substructure walls

Where drains pass through structural elements, allowance should be made to accommodate movement.

Pipes passing through substructure walls should accommodate movement by:

- a 50mm clearance all round
- a sleeve, with 50mm clearance all round and suitably sealed, or
- bedded pipes, connected on both sides of the wall with flexible joints located as close as is feasible to the outside face of the wall but at a maximum of 150mm from the face of the wall.

Flexible joints should be made in accordance with the pipe manufacturer's recommendations.

Figure 12: Pipe laid in clearance hole with lintel over

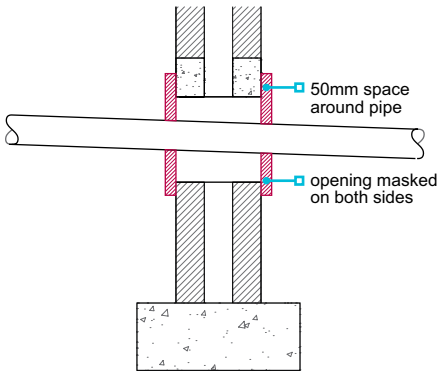
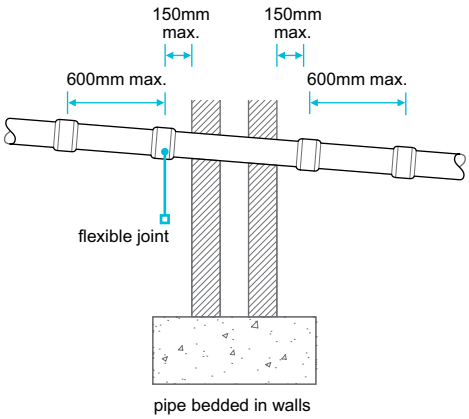


Figure 13: Pipe bedded in walls



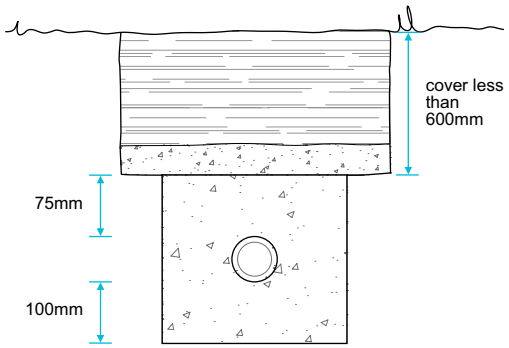
5.3.14.2 Pipework under finishes

Where drains pass under roads and drives, the final compaction should be sufficient to prevent later settlement.

Table 10: Pipework protection in utility areas

Rigid pipes less than 1.2m below road surface	Should have: • where necessary, a minimum 100mm concrete encasement • movement joints formed with compressible board at each socket or sleeve joint face • flexible joints which remain flexible.
Flexible pipes less than 0.9m below road surface	Should be protected by concrete bridging slabs, or surrounded with reinforced concrete as appropriate
Garden areas	Where flexible pipes are not under a road and have less than 600mm cover, where necessary they should have: • concrete paving slabs laid as bridging above the pipes • a minimum 75mm of granular material between the top of the pipe and underside of the slabs.

Figure 14: Pipe protection in soft landscaped area

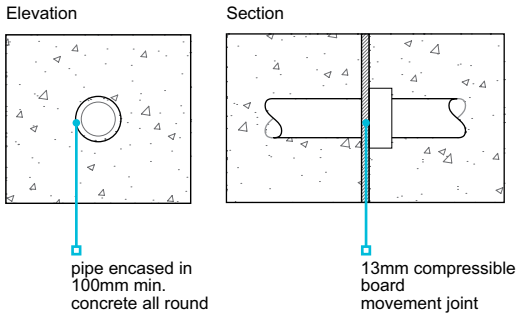


5.3.14.3 Movement joints

Where rigid pipes are to be encased in concrete, movement joints should be:

- provided around the spigot next to the socket either at 5m maximum intervals or at each joint
- 13mm thick compressible board.

Figure 15: Movement joint detail in concrete cased pipes



5.3.15 Laying pipework

Pipework shall be laid to the designed lines and gradients. Issues to be taken into account include:

1) bedding

2) sidefill and backfill.

5.3.15.1 Bedding

Pipes should be firmly supported throughout their length and bedded as specified in the design to resist loads from overlying fill and traffic.

Where pipework is installed under a suspended floor and is supported on ground or fill where movement is likely to occur, additional provisions may be required (see Clause 5.3.8).

Bricks, blocks or other hard material should not be used as temporary supports to achieve the correct gradients, as they may create hard spots which can distort the completed pipe run.

Pipes should be either:

- bedded on granular material, minimum 100mm deep, or
- laid directly on the trench bottom, where the trench bottom can be accurately hand trimmed with a shovel but is not so soft that it puddles when walked on.

For 150mm diameter and 100mm diameter drains, a bed and surround granular material like pea gravel in accordance with Table 8 (to a thickness of 100mm all round the drain) will be acceptable for drains under gardens, paths and drives.

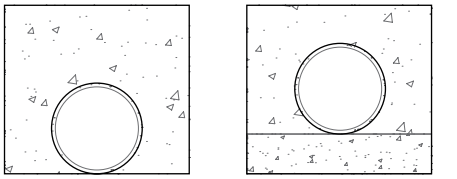
Proprietary systems should be assessed in accordance with Technical Requirement R3 and supported in accordance with the manufacturer's recommendations. Some proprietary systems permit a minimum of 50mm depth of bedding in certain circumstances.

Depressions should be formed where necessary in the trench bottom to accommodate pipe joints.

Pipe bedding, including the bedding material, should be in accordance with:

- BS EN 13242
- BS EN 1610
- BS EN 752.

Figure 16: Pipe bedding construction types 1 and 3 to EN 1610



Bedding material and specification should be in accordance with Table 11. Backfill and bedding that includes recycled or secondary materials should conform to the appropriate regulatory requirements for waste, as defined in the Waste Framework Directive 2008.

Table 11: Bedding size

Nominal pipe size	Bedding material complying with BS EN 13242
110mm flexible pipes 100mm rigid pipes	4/10mm pipe bedding gravel
160mm flexible pipes 150mm rigid pipes	2/14mm pipe bedding gravel

5.3.15.2 Sidefill and backfill

Sidefill and backfill should be placed as soon as the pipes have been bedded, jointed and inspected.

Sidefill should be either granular material or selected backfill material from the trench excavation, free from:

- stones larger than 40mm
- clay lumps larger than 100mm
- timber
- frozen material
- vegetable matter.

Backfill should be well compacted and placed in layers no deeper than 300mm. Mechanical compacting should only be used when compacted backfill is over 450mm above the crown of the pipe.

Figure 17: Hand compaction directly above pipe crown

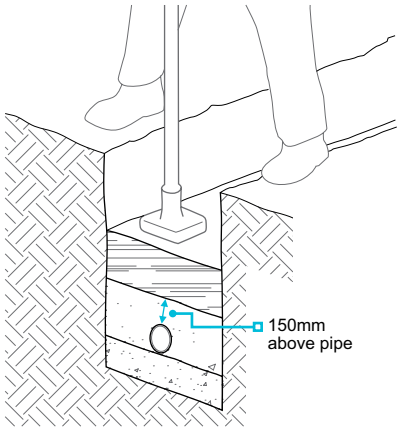
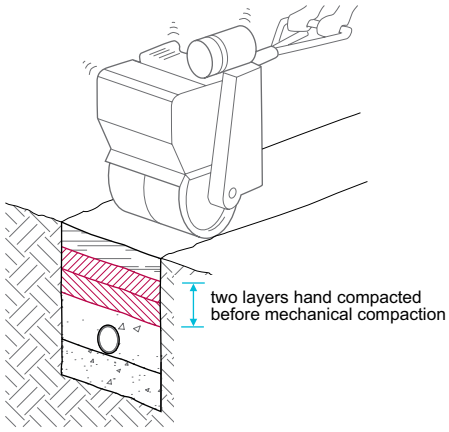


Figure 18: Machine compaction to complete trench backfill



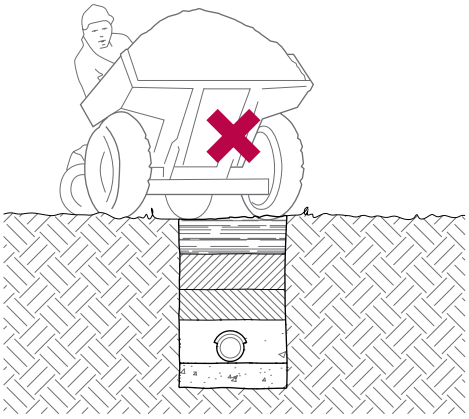
5.3.16 Protection of work

Drainage systems shall be suitably protected from damage by construction work.

Damaged drainage will not be accepted, and it is recommended that:

- no heavy loading or underground work is permitted above, or near, unprotected drainage
- dumpers, trucks, fork lifts or other heavy vehicles are not driven along, or near, pipe runs.

Figure 19: Protection of backfilled drainage trenches from construction work



5.3.17 Drainage under buildings

Drainage system under buildings shall be suitably designed and supported to ensure an effective and satisfactory performance for the life of the building. Issues to be taken into account include:

1) ground supported pipework
2) suspended drainage
3) examples of site installations
4) drainage beneath specialist foundations.

Pipework support should take account of the ground conditions and ensure that the drainage is not adversely affected by ground movement.

Pipework under suspended floors should not be supported on ground or fill that is susceptible to movement without adequate provision being made to:

- maintain minimum design gradients
- protect against backfall
- protect against leakage.

See Clause 5.3.14 for Pipework passing through substructure walls.

5.3.17.1 Ground supported pipework

Where the ground is not at risk of settlement or heave, drainage can be installed in a trench with suitable bedding and backfill.

Where fill is used to support drainage on made-up ground at risk of settlement, it should be a maximum depth of 600mm, well graded, inert and without hazardous materials.

The fill should be placed and mechanically compacted in layers not exceeding 225mm in depth, to form a stable mass. Any fill in excess of 600mm which supports drainage should be designed by an engineer to avoid settlement. Drainage pipes should be bedded into the compacted fill.

In ground at risk of settlement, drainage can be laid in the normal manner, but at a steeper gradient than recommended minimums, to allow for any settlement and avoid backfalls. Easy or rest bend connections to above ground drainage can be made with proprietary settlement pipe sockets, which provide for more movement than a standard pipe socket connection. Alternatively, drainage can be suspended.

5.3.17.2 Suspended drainage

In ground at risk of significant heave or settlement, a suspended drainage installation should be used.

Pipe supports should be adjustable to achieve a consistent gradient and rigid enough for rodding without causing dislodgement. Support brackets should be suitable for an underfloor environment. Lightly pre-galvanised thin strapping can easily rust and collapse, so it should not be used. Purpose-made stainless steel or suitably galvanised brackets should be used.

Where suspended horizontal drainage is used, it should be supported as per the manufacturer's recommendations, typically 900mm to 1,000mm centres for 110mm nominal diameter pipes and at every socket or joint. Long pipe runs (typically 5m or greater) should be designed to accommodate thermal movement.

5.3.17.3 Examples of site installations

Ground supported drainage are often seen bedded, backfilled and strapped to suspended floors as shown in photos 1 and 2. In many cases, the strappings are flexible lightly galvanised type, fixed to floor beams on one side of the drain. These are unacceptable as ground settlement here can cause the straps to pull the drain out of alignment. Equally, such strappings are less able to resist movement of the pipework during rodding, thereby increasing the risk of disconnection and leakage.

Where a fully suspended design is adopted, rigid proprietary brackets which clamp around the drainage pipe and have adjustable threaded support rods should be used eg as shown in photos 3-5. Some brackets clamp to concrete beams, and others are built into the floor structure. In each case, it is necessary to ensure the pipes are fully supported at the sockets and at horizontal centres in accordance with the pipe manufacturer's instructions.

Photo 1

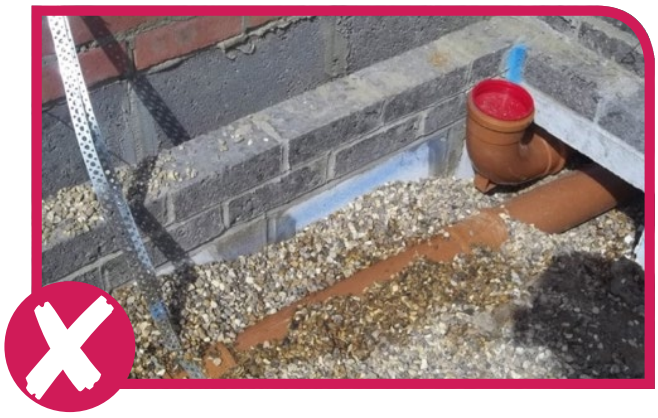


Photo 2

Photo 3

Photo 4

Photo 5

5.3.17.4 Drainage beneath specialist foundations

Where drains are located beneath raft foundations or where ground movement is likely, the design of the pipework and support system should be carried out by a suitably qualified engineer in accordance with Technical Requirement R5.

5.3.18 Testing

All foul and surface water drainage systems shall be adequately watertight, and tested where appropriate.

Inspection and testing should be arranged when required by:

- the local authority
- the sewerage undertaker
- NHBC.

Before backfilling, visual inspections are required and the builder is advised to test. When the home is handed over, the system must be in full working order and free from obstruction.

5.3.19 Further information

- *BS 6297 — Code of practice for the design and installation of drainage fields for use in wastewater treatment*
- *BS EN 752 — Drains and sewer systems under buildings. Sewer system management*
- *BRE Report 211 — Radon. Guidance on protective measures for new buildings*
- *BRE Report 212 — Construction of new buildings on gas-contaminated land*
- *BRE Digest 365 — Soakaway design. 2016 Edition*
- *SFA 7 — Sewer for Adoption. A design and construction guide for developers. 7th Edition*

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