

Code of practice for

Building drainage —

(Formerly CP 301)

UDC 628.6:696.12/.13:628.2

Committees responsible for this British Standard

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- Association of District Councils
- British Board of Agrément
- British Ceramic Research Association
- British Foundry Association
- British Plastics Federation
- British Precast Concrete Federation Ltd.
- British Steel Industry
- Building Employer’s Confederation
- Cement and Concrete Association
- Chartered Institute of Building
- Clay Pipe Development Association Limited
- Concrete Pipe Association
- Department of the Environment (Building Research Establishment)
- Department of the Environment for Northern Ireland
- Department of the Environment (Housing and Construction Industries)
- Department of the Environment (Property Services Agency)
- Ductile Iron Producers’ Association
- Fibre Cement Manufacturers’ Association Limited
- Health and Safety Executive
- Incorporated Association of Architects and Surveyors
- Institute of Clerks of Works of Great Britain Inc.
- Institute of Environmental Health Officers
- Institute of Plumbing
- Institution of Building Control Officers
- Institution of Municipal Engineers
- Institution of Public Health Engineers
- Institution of Structural Engineers
- Institution of Water Engineers and Scientists
- London Boroughs Association
- National Coal Board
- Royal Institute of British Architects
- Scottish Development Department
- Union of Construction — allied Trades and Technicians
- Water Authorities Association

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Foreword

This code, prepared under the direction of the Building Services Standards Committee, is a complete revision of CP 301 and supersedes the 1971 edition which is withdrawn.

The revision takes into account developments since 1971 in materials used in drainage together with recent advances in drain clearing methods affecting access to pipelines.

It emphasizes the need for pipeline flexibility for the avoidance of failure from ground movement and has adopted a computed load method for structural design.

The code does not define in legal terms any hard and fast boundary between the drainage systems covered by this code and the sewerage systems covered by CP 2005. It is mainly concerned with pipelines comprising DN 100 and DN 150 pipes but includes recommendations appropriate for pipes up to about DN 300 which are used in building development. For larger pipework CP 2005 should be consulted and efforts have been made to ensure, where the two codes overlap, that inconsistencies do not occur.

The terminology used in describing drainage has developed over a long period, during which important changes in design, materials and installation techniques have taken place. These have made possible a more rational approach to design, and encouraged simplicity and economy in presentation.

Although materials referred to in this code are mainly traditional and covered by British Standards, the use of new materials and new applications of established materials are not precluded where it can be demonstrated that they are satisfactory for their purpose.

As regards the testing of inspection chambers and manholes for watertightness, and the recommendation of performance criteria for these units, the committee has felt the need for further data and research. These topics will therefore be the subject of continuing work on the committee and appropriate amendments to the text will be made as soon as possible.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 70, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This code sets out recommendations for the design, layout, construction, testing and maintenance of foul, surface water and groundwater drainage systems constructed in the ground under and around buildings, and their connection to sewers, treatment works, cesspools, soakaways or watercourses.

The structural design criteria are limited to drains not generally exceeding DN 300, although the other criteria are of general application.

NOTE The titles of the BSI publications referred to in this standard are listed on the inside back cover. References in the text to other publications are identified in the text by numbers in square brackets, and are listed in Appendix A.

2 Definitions

For the purposes of this code the definitions of drainage terms given in BS 892, BS 4118, BS 5572 and BS 6100 apply. Some of these are repeated here for convenience. Other definitions not given in the above standards are included and these also apply.

2.1

blinding

material that will fill the interstices and irregularities in the exposed trench bottom and, when adequately compacted will create a firm uniform formation on which to place the pipe bedding material

NOTE Hoggins, sand, gravel, all-in aggregate or lean concrete are commonly used.

2.2

branch drain

a line of pipes installed to discharge into a junction on another line or at a point of access, i.e. an access junction, inspection chamber or manhole

2.3

branch vent

a ventilating pipe connected to one or more branch drains

2.4

discharge unit

a unit of flow calculated for a drainage appliance so that the relative load-producing effect of its discharge can be expressed as a multiple of that unit

NOTE The discharge unit load of an appliance depends on its rate and duration of discharge, the interval between discharges and the chosen criterion of satisfactory service (see 7.4.3.2). It is not a simple multiple of a rate of flow (see BS 5572).

2.5

drop-pipe connection

a vertical connection to or near the invert level of a manhole from a sewer or drain at a higher level

2.6

foul water

any water contaminated by soil, waste or trade effluent

2.7

junction

a fitting on a pipeline designated to receive discharges from a branch drain(s)

2.8

inspection chamber

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

2.9

manhole

a working chamber with cover constructed on a drain or sewer within which a person may inspect, test or clear and remove obstructions in safety

2.10

nominal size (DN)

a numerical designation of the size of a pipe, bend or branch fitting, which is a convenient round number approximately equal to a manufactured dimension

NOTE "Nominal bore" is the approximate internal diameter of a unit as declared by the manufacturer. This quantity is quoted with units (mm) whereas nominal size (DN) is quoted without units.

2.11

storm water

rainwater discharged from a catchment area as a result of a storm

3 Exchange of information

3.1 General

The full exchange of information between all the parties concerned is essential before drainage work is begun. Close liaison should be maintained with all appropriate authorities. In general, the information in 3.2 to 3.10 should be provided. Recommendations on the preparation of plans are given in Appendix B.

3.2 From owner or user to designer

- a) A plan of the site showing existing and proposed levels preferably related to Ordnance Datum, indicating the position and floor levels of the proposed building and the ground levels and contours of the site, including any proposed regrading.

b) Details of the positions and types of all appliances requiring drainage, the location and extent of all paved areas and the position of all existing sanitary pipework, rainwater pipes and gullies.

c) The nature of the discharges and the nature and volume of any trade effluents involved.

d) The number of occupants and the periods of occupation.

3.3 From sources of technical information to designer

3.3.1 From the local authority and/or water authority

a) Building regulations and other requirements of legislation (see clause 4).

b) Whether adequate sewerage is available to receive the proposed discharge(s).

c) The conditions under which any trade effluents may be accepted.

d) The position, size and level of the public sewer(s) and manhole(s).

e) The system of sewerage, i.e. separate, partially separate or combined.

f) The materials of construction and the condition of the sewer(s).

g) Relevant water table levels, flood water levels and their seasonal and other variations.

h) Whether interceptors are required.

i) The positions and levels at which connections may be made, taking account of surcharge conditions.

j) Any relevant local byelaws or further design requirements.

k) By whom the connections will be made: if by the authority, the estimated cost; if by the developer or contractor, the requirements of the authority.

l) The limits of responsibility for installation and maintenance.

m) Where sewerage is not available a separate system should be designed. The authority should be consulted on their requirements for the storage or treatment of sewage and disposal of effluent; whether to natural watercourse, ditch or land drainage; also for the disposal of surface water to soakaway, ditch or natural watercourse.

n) The physical and chemical nature of the ground to be excavated, particularly as regards the presence of sulphates. The client is responsible for making his own soil survey but the local authority should pass on any relevant local knowledge.

3.3.2 From other authorities

a) *Highway authority and the police.*

Requirements as regards drains underpassing roads and reinstatements thereafter.

Requirements regarding control and/or diversion of vehicles and pedestrians where drains cross roads or footpaths.

b) *Local mining authority.* Information on subsidence.

c) *Electricity, gas and water supply authorities.*

Location of all present and relevant future services. Owners of such services should be given notice of the intention to excavate. Some will possess statutory powers to exact an indemnity against damage to their buried services and to prescribe special precautions against damage during excavation.

d) *Building owner.* Details of any wayleaves negotiated where a drain crosses land in other ownership. The exact location of manholes should be shown on wayleave plans particularly where drains are laid in fields or other open ground. The right of access to manholes and the right to maintain or renew the drain should be specifically included in any wayleave arrangements made with the owner of the land. Certain provisions relating to drains laid in the land of other owners appear in Section 16 of the Water Act 1973 and may present an alternative to wayleaves.

Details of any prior damage to buildings and structures near where trenches have to be excavated. Inspection, preferably with the owners of the property, should be made before starting the work, to establish whether any visible defects exist and a survey and records of the condition of buildings likely to be affected should be made. Dated tell-tales may be placed across any cracks and kept under observation. Photographic evidence may prove useful.

e) *BSI.* See references herein to appropriate codes and specifications.

3.4 From designer to drainage authority

a) Proposal to connect to the public sewerage system.

b) Information and plans in the prescribed form. Normally the drainage plans form part of the general building drawings submitted (see Appendix B).

c) Estimated dry weather flow, peak rates of flow and character of sewage with particulars of any trade effluent.

d) At the conclusion of the work, plans should be lodged with the authority recording details of the work as installed (see Appendix B).

3.5 From designer to contractor

- a) Adequate detailed drawings with the specification for the work.
- b) Full details of any special requirements of the authorities and in respect of wayleaves or other matters.

3.6 From designer to owner

- a) Full detailed drawings for the record of the work as installed.

3.7 From contractor to building control authority

- a) Submission of plans for warrant approval (Scotland).
- b) Prior notice of intention to commence work.
- c) Notice prior to haunching in concrete or covering in any way. Notice of readiness for first testing (Scotland).
- d) Notice after backfilling. Notice for readiness for final testing (Scotland).
- e) Notice of completion of work.

3.8 From contractor to drainage authority

- a) Notice of intention to connect to a sewer or other means of disposal.

3.9 From contractor to designer

- a) Details of any deviations from working drawings.
- b) Notification of start and finish of work and interim progress reports.
- c) Details of any unforeseen difficulties.

3.10 From contractor to highway authority

- a) Full details in respect of highway opening notices.

4 Enactments and official recommendations

4.1 General

There are a great number of Acts and Regulations affecting the powers or duties of local authorities, water undertakings and, in Northern Ireland, the Department of the Environment, in connection with drains and sewers; the following list includes the most important but is not intended to be complete:

England and Wales

Building Regulations
Public Health Act 1936
Public Health (Drainage of Trade Premises) Act 1937
Highways Act 1980
Public Health Act 1961
London Government Act 1963
Local Government Act 1972
Water Act 1973
Control of Pollution Act 1974

Scotland

Building (Scotland) Acts 1958 and 1970 as amended
The Building Standards [Scotland] Regulations 1981
Sewerage (Scotland) Act 1968
Control of Pollution Act 1974

Northern Ireland

Water Act (NI) 1972
The Building Regulations (NI) Order 1972
(The Building Regulations (NI) 1977)
Water and Sewerage Services (NI) Order 1973

4.2 Safety

The Health and Safety at Work etc. Act 1974 and the relevant regulations made thereunder apply to execution of the works on site. The recommendations of the booklet "Safe working in sewers and at sewage works" published by the National Joint Health & Safety committee for the Water Service, should be observed [1].

Section 2. Materials and components

5 Materials and components

5.1 Selection of materials

The materials for pipes, pipe joints, bedding, associated building works and the type of cement and mix to be employed should be selected to ensure satisfactory service for the life of the drainage system. Factors to be taken into account include:

- a) the type of usage likely to occur and the nature of the liquids to be conveyed;
- b) the nature of the ground and the possibility of chemical attack therefrom;
- c) the physical and chemical characteristics of the drainage materials themselves;
- d) the possibility of erosion by solids in the flow or of chemical attack;
- e) the quality of workmanship that may be expected;
- f) the degree of supervision to be provided.

Recommendations for the most commonly used drainage materials are given in the following paragraphs. Reference should be made to BS 5493 and to PD 6484 for advice on corrosion problems.

5.2 Cement

Cement used for building drainage work should comply with the requirements of BS 12, BS 146, BS 915, BS 4027 or BS 4248 (see 5.4.1). The most commonly used are ordinary and rapid hardening Portland cements. The “deemed to satisfy” provisions in the Building Regulations 1976 do not include the use of high alumina cement to BS 915 for structural work.

5.3 Aggregates

5.3.1 Aggregates for concrete. Aggregates for concrete should comply with the requirements of BS 882 or BS 1047. The nominal size of coarse aggregate should be as large as practicable within the limits specified in the appropriate British Standard, provided that the concrete can be satisfactorily placed and compacted. Where tests are required they should be carried out in accordance with BS 812.

5.3.2 Aggregates for mortar. The fine aggregate for mortar for brickwork or blockwork should comply with the requirements of BS 1200. Sands for rendering should comply with the requirements of BS 1199. Sands for jointing of pipelines or precast concrete manholes should generally comply with one of these standards or alternatively may be fine concreting sands complying with BS 882 from which the excess coarse material has been removed.

5.4 Concrete

5.4.1 General. The recommended mixes for in situ concrete used in building drainage work are given in Table 1. In the case of the prescribed mixes given in Table 1 the grade is in terms of a number which will normally (but not contractually) be its 28 day characteristic strength (N/mm^2). Where compliance is to be by strength a designed mix should be specified. In addition to strength it will also be necessary to specify cement content and water cement ratio to ensure adequate durability. Reference should be made to BS 8110¹⁾ and BS 5328.

Aqueous solutions of sulphates, as may be present in some soils and groundwater, can cause expansion and disruption of concrete. Concrete containing ordinary Portland cement should not, unless combined with appropriate proportions of pulverized-fuel ash (p.f.a.) or slag, be used in contact with soils above class 2 classification. Unprotected concrete containing sulphate-resisting cement may be used in soils up to class 4 classification. Above this classification an adequate protective coating should be provided.

Recommendations for the type of cement, maximum free water content and minimum cement content required for different sulphate concentrations may be found in BS 8110¹⁾ and BRE Digest 250 [2]. These recommendations should be followed for any main structural work but for the majority of applications covered by this code it will be acceptable to select a mix from Table 1.

Concrete made with Portland cements is not recommended in acidic conditions.

Sulphate-resisting Portland cement does not differ significantly from ordinary Portland cement in its acid resistance but where sulphates are present in a low acidic solution its use may give improved durability.

In conditions where the pH is less than 6 or in situations such as industrial sites, where conditions may be very aggressive to any concrete, special advice should be obtained.

Fresh sewage is not normally aggressive to Portland cement concrete and mortar, but attack may occur as a result of an aggressive groundwater, discharge from hospitals, from trade or industrial processes or septic sewage conditions which give rise to hydrogen sulphide resulting in the formation of sulphuric acid. In such circumstances the nature and quantities of such discharges should be ascertained and expert advice should be obtained and followed. Hot liquids may be more aggressive than those at normal ambient temperatures.

¹⁾ In preparation. Revision of CP 110.

5.4.2 Admixtures. The use of admixtures for promoting workability, for improving strength, for entraining air or for any other purpose should be permitted only with prior agreement of the designer.

Calcium chloride as an admixture should not be used in reinforced concrete, prestressed concrete or any concrete made from sulphate-resisting Portland cement. For guidance reference should be made to BS 8110¹⁾-1.

5.5 Cement mortar

Selection of the correct cement for use in mortars should take account of the considerations set out in 5.1 to 5.3. A mortar mix having a 1 : 3 cement/sand ratio is suitable for the following purposes:

- a) rigid joints for clay or concrete pipes;
- b) rendering of inverts and benchings;
- c) jointing concrete manhole sections.

A mix of 1 : $\frac{1}{4}$: 3 cement/lime/sand is recommended for brickwork mortar.

5.6 Pipes, joints and fittings

5.6.1 Factors affecting choice of materials and systems. Whatever selection is made, pipes should have adequate strength to meet loading requirements, be sufficiently robust to withstand site handling and be sufficiently durable to remain watertight for the anticipated life of the system. Pipes and joints should remain sufficiently watertight to prevent ingress of ground water and egress of effluent when subjected to ground movement and settlement. Pipe sizes available in various materials are given in Table 2.

In addition to those factors listed in 5.1, consideration should also be given to the diameters and lengths of pipes available, ease of cutting, simplicity of the jointing system, the range of fittings available, ease of unloading and positioning in the trench without damage to the pipe or to any coating.

The coatings most commonly applied to metal pipes do not necessarily provide adequate protection against all types of corrosion. Specially designed coatings may be required for protection against concentrations of acids, alkalis, sulphates and other aggressive chemicals likely to be encountered in the ground and in liquids carried. An indication of the resistance to chemical attack of available pipe and jointing materials for various liquids and groundwater, is given in Table 3.

Flexible joints are generally available for the range of materials used for drainage and they can accommodate angular deflection, axial displacement and draw within the joint. They are designed to resist shear loads without loss of watertightness. Where rigid joints are required they can be made by caulking metal or compound or by working a cement mortar into the joint, by bolted flanges or by welding the pipes together. Care should be taken on such jointing operations not to disturb the gradient of the line or the continuity of the bore.

Brief information on available pipes is given below. For further information, reference should be made to the appropriate British Standard.

Table 1 — Recommended mixes for buried concrete

Use of concrete	Soil conditions			
	Sulphate classification (see note 2)			
	Class 1 or less	Class 2	Class 3	Class 4
Concrete for backfilling of trenches	C 10 P (see note 3)	C 20 P	C 25 P	C 30 P
Structural protection of buried pipelines	C 20 P	C 20 P	C 25 P	C 30 P
Structural plain concrete, e.g. foundations to manholes	C 20 P	C 25 P	C 25 P	C 30 P
Reinforced concrete	C 25 P	C 25 P	C 25 P	C 30 P
Cement type	OPC	SRPC		

NOTE 1 The above grades of concrete are those described in BS 5328 as ordinary prescribed mixes. The grade is in terms of a number which will normally (but not contractually) be its 28 day strength.

Where designed mixes are used for other work on the same site, consideration should be given to their use for underground drainage work.

NOTE 2 These mixes are only suitable in near-neutral ground conditions pH 6 to pH 9 (see 5.4.1 and BRE Digest 250 [2] for definition of soil classifications).

NOTE 3 Lean mix concrete may be used where sulphates are not present (see 5.7.6.3).

5.6.2 Rigid pipes

5.6.2.1 General. The materials for these pipes show linear, brittle stress-strain behaviour. The pipes do not deform appreciably under their design load. Thus the ability of a rigid pipe to support the total load transmitted to it is established by reference to actual crushing tests.

5.6.2.2 Asbestos-cement. Asbestos-cement pipes and fittings for gravity drainage are manufactured to BS 3656 in diameters from 100 mm, in lengths 3 m, 4 m and 5 m and to the strength classifications given in that standard. Half and quarter length pipes are also available. Pressure pipes are manufactured to BS 486 in diameters from 50 mm and in lengths 3 m and 4 m. Cast iron fittings for use with these pipes are also available. Both of these standards include requirements for flexible joints.

5.6.2.3 Vitrified clay. Vitrified clay pipes and fittings in preferred nominal diameters from 100 mm are manufactured to BS 65 in lengths of 0.3 m to 2.5 m in three strength classifications as given in that standard. The standard also includes requirements for flexible joints, perforated pipes and extra chemically resistant pipes.

5.6.2.4 Concrete. Plain and reinforced concrete pipes and fittings are manufactured to BS 5911 in diameters from 150 mm in lengths of 0.9 m to 2.5 m and to the strength classifications given in those standards, which include requirements for flexible joints.

5.6.2.5 Grey iron. Pipes and fittings to BS 437 are manufactured in grey iron in diameters from 50 mm. Standard pipe lengths are 1.83 m, 2.74 m, 3.66 m and 5.5 m (except that those of 50 mm diameter are in 1.83 m lengths only). These pipes or fittings have run or caulked lead joints. BS 437 permits the use of flexible joints and proprietary flexible couplings are available. BS 6087 specifies flexible joints for use with these pipes.

Grey iron pressure pipes are manufactured to BS 4622 in diameters from 80 mm. They are available with caulked lead, flanged or flexible joints. Standard pipe lengths are 5.5 m for pipes with caulked lead or flexible joints, 4.0 m for pipes with screwed-on flanges and 0.75 m or 1.0 m for pipes with cast-on flanges.

5.6.3 Flexible pipes

5.6.3.1 General. The materials for these pipes show ductile stress-strain characteristics. Flexible pipes deform under load and the extent of this deformation depends upon the stiffness of the pipe and the compaction of the immediate surrounding fill. Some plastic pipe materials may display cold flow or regression of strength characteristics. When GRP, pitch fibre and uPVC pitch fibre pipes are installed with bedding materials, properly compacted in accordance with this code they will not generally be deformed by more than 5 % of their original diameter, which is considered acceptable.

5.6.3.2 Ductile iron. Ductile iron pressure pipes and fittings are manufactured to BS 4772 in diameters from 80 mm and to BS 437 in diameters from 50 mm. They are available with flexible or flanged joints. Standard lengths are 5.5 m or 4.0 m for pipes with the two types of joint respectively.

5.6.3.3 Glass fibre reinforced plastics (GRP). GRP pipes and fittings manufactured to BS 5480 are available with diameters from 25 mm and in lengths of 3 m, 5 m, 6 m, 10 m and 12 m. Experience of their use in building drainage in the UK is limited. It is known that their life may be adversely affected by continuous conveyance of hot liquids and, since the term GRP covers a wide range of materials, they may have differing characteristics. It is essential that the manufacturer be consulted regarding their use.

5.6.3.4 Text deleted

5.6.3.5 Steel. Steel pipes and joints are manufactured to BS 534 with outside diameters from 60.3 mm. Protection against corrosion by the liquid carried and by groundwater and by anaerobic attack is necessary.

5.6.3.6 Unplasticized PVC (uPVC). uPVC pipes and fittings for gravity drainage with flexible or rigid (solvent welded) joints are manufactured to BS 4660 in outside diameters of 110 mm and 160 mm, and to BS 5481 in outside diameters of 200 mm upwards. Pipes are generally available in lengths of 3 m, 6 m and 9 m.

For pressure drainage systems uPVC pressure pipes are manufactured to BS 3506 in nominal size from 3 (DN 75). Fittings for uPVC pressure pipes are manufactured to BS 4346.

If it is proposed to use these pipes and fittings with untreated trade waste or with prolonged discharges at temperatures greater than 60 °C reference should be made to BS 5955 and/or to the manufacturer.

Table 2 — Pipe size as defined in BS 8301 and individual pipe standards

	Rigid pipes						Flexible pipes						
	Asbestos		Clay	Concrete	Grey iron		Ductile iron	GRP	Pitch fibre	Steel	Unplasticised PVC		
	BS 3656	BS 486	BS 65	BS 5911	BS 437	BS 4622	BS 4772	BS 5480	BS 2760	BS 534	BS 4660	BS 5481	BS 3506
Nominal size	Nominal bore	Nominal bore	Nominal bore	Nominal bore	Nominal bore	Nominal bore	Nominal bore	Nominal bore	Nominal bore	Outside diameter	Outside diameter	Outside diameter	Min. outside diameter
DN	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
75	—	75	^a 75	—	75	80	80	80	75	76.1 88.9	—	—	88.7
100	100	100	100	—	100	100	100	100	100	114.3	110	—	114.1
125	125	—	—	—	—	—	—	125	125	139.7	—	—	140.0
150	150	150	150	150	150	150	150	150	150	168.3	160	—	168.0
175	175	—	—	—	—	—	—	—	—	193.7	—	—	193.5
200	200	200	^a 200	—	—	200	200	200	200	219.1	—	200	218.8
225	225	225	225	225	225	—	—	—	225	244.5	—	—	244.1
250	250	250	^a 250	—	—	250	250	250	—	273.0	—	250	272.6
300 ^b	300	300	300	300	—	300	300	300	—	323.9	—	315	323.4
^a Non preferred sizes.													
^b Although not covered in this code, pipes in many of these materials are available in diameters greater than 300 mm. These are dealt with in CP 2005.													

Table 3 — Chemical resistance of materials (for general guidance)

Group	BS no.	Material and applications	Normal domestic sewage	Trade effluent								
				At normal temperature		Organic solvents	Containing oils and fats		At sustained high temperature		Soil environment containing	
				Acids	Alkalis		Vegetable	Mineral	Acids	Alkalis	Sulphates	Acids
Ceramics	65, 1196 3921	Clayware pipes and fittings	A	S	S	S	S	S	A	A	S	S
		Bricks and blocks of fired brick-earth, clay or shale	A	S	S	S	S	S	A	A	S	S
Concrete	5911	Concrete: ordinary Portland cement sulphate-resisting Portland cement	A	E	A	A	E					
			A	E	A	A	E	A	E	A	E	E
Asbestos cement	486 3656	Asbestos cement pressure pipes and joints										
		Asbestos cement pipes, joints and fittings (gravity) for sewerage and drainage	A	E	A	A	E	A	E	A	A	E
Metals	534	Steel pipes and fittings	A	E	A	A	A	A	E	E	E	E
	437	Grey iron pipes and fittings (gravity)	A	E	A	A	A	A	E	E	E	E
	4622	Grey iron pipes and fittings (pressure)										
	4772	Ductile iron pipes and fittings										
Plastics	4660	uPVC	A	S	S	E	A	A	E	E	S	S
	5481 3506	} gravity drain and sewer pressure										
	5480											
Joining materials [other than Portland cement and iron and steel components (see under pipes)]	2494	Rubber: natural (NR)	A	A	A	E	E	E	E	A	A	A
		chloroprene (CR)	A	S	A	E	A	A	A	A	S	S
		BUTYL (IIR)	A	S	S	A	A	A	A	A	S	S
		styrene-butadiene (SBR)	A	A	A	E	E	E	A	A	A	A
		nitrile-butadiene (NBR)	A	A	A	E	A	A	E	A	A	A
		ethylene-propylene terpolymer (EPDM)	A	A	A	E	A	E	A	A	A	A
		ethylene-propylene copolymer (EPM)	A	A	A	E	A	E	A	A	A	A
		^a Bituminous compositions	A	A	A	E	E	E	E	A	A	A
		^a Polyester resin	A	S	A	E	A	A	E	E	S	S
		Polyethylene: (Type 32) cold water services	A	A	A	A	S	A	A	A	S	S
	1972	(Type 32) general purposes including chemical and food										
		(Type 50) cold water services										
		(Type 50) general purposes including chemical and food										
		^a Polyurethane	A	S	S	A	S	A	A	A	S	S
6437	^a Polypropylene	A	S	S	A	S	A	A	A	S	S	
	^a Epoxy	A	A	S	E	E	A	E	S	S	A	

A = normally suitable.

E = need expert advice, each case to be considered on its own merits.

S = specially suitable.

NOTE It is important to take account of **quantities and concentrations** of all types of chemical likely to be encountered.^a There are no relevant British Standards for these joining materials. The classification given to them in the table assumes that the formulations and methods of curing employed are those appropriate for pipe jointing.

The impact strength of uPVC pipes is reduced in cold weather during which extra care in handling should be exercised. Further guidance on handling, support, transport and installation is given in BS 5955-6.

5.6.3.7 Polyethylene. Polyethylene pressure pipes are manufactured to BS 1972, BS 1973, BS 3284 and BS 6437. Jointing can be effected either by fusion jointing or by means of compression fittings.

5.6.4 Pipes for field drains. Open-jointed pipes or porous or perforated pipes of the following types may be used for field drains:

- a) clayware field drain pipes to BS 1196 and vitrified clay pipes to BS 65 (surface water quality pipes or perforated pipes);
- b) concrete pipes to BS 5911;
- c) plastics pipes to BS 4660, BS 4962 and BS 5481;
- d) porous concrete pipes to BS 1194.

Concrete pipes may be unsuitable where subsoil water carries sulphates or is acidic owing to the presence of peat.

5.7 Miscellaneous materials and components

5.7.1 Manholes

5.7.1.1 Inspection covers, manhole covers and frames. Cast grey and ductile iron and cast steel inspection covers, manhole covers and frames should comply with BS 497-1.

5.7.1.2 Pre-cast concrete inspection chamber and manhole sections. Concrete inspection chamber and manhole sections and pre-cast cover slabs should comply with BS 5911-1 and BS 5911-2.

5.7.1.3 Step irons. Step irons should comply with BS 1247.

5.7.1.4 Steel ladders. Steel ladders for permanent access should comply with BS 4211.

5.7.2 Gullies and gratings

5.7.2.1 General. A gully usually incorporates a trap, or a sump, or both, to retain detritus. The top should be fitted with either a grating or a sealed cover. Connections should be made below the grating or cover. Gullies may be specially designed to suit selected locations and the volume and nature of the flow. They can also incorporate means of access for rodding the branch drain beyond the trap. Gullies and gratings are available in various materials as detailed in 5.7.2.2 to 5.7.2.6.

5.7.2.2 Cast iron. Cast iron gullies and assemblies should comply with BS 437.

5.7.2.3 Clayware. Clayware waste, rainwater, yard, garage and road gullies should comply with BS 65 which specifies general performance requirements.

5.7.2.4 Concrete. Pre-cast concrete gullies for drainage of roads and paved areas should comply with BS 5911-2.

5.7.2.5 Plastics. Plastics gullies are manufactured in glass reinforced plastics, polyethylene, polypropylene and uPVC. Where hot liquids or chemicals may be discharged or where they may be subjected to vehicular wheel loadings, the manufacturer's advice should be obtained.

5.7.2.6 Gully gratings. Gratings and, where provided, frames should be suitable for the gullies with which they are to be used and should be capable of supporting the loadings likely to be encountered in use without excessive deformation or failure. Cast grey and ductile iron and steel road gully gratings and frames should comply with BS 497-1.

5.7.3 Bricks. Bricks should be at least class B engineering bricks complying with BS 3921 and should additionally be subject to the limitation of twist and bow to ± 2 mm when measured by the methods applied to clay blocks in clauses 17 and 18 of BS 3921:1974. The bricks should be of sufficient compressive strength to withstand any super-imposed loads likely to be experienced in use. Frogless bricks are to be preferred but, if frogged, frogs should face upwards. If double frogged bricks are used they should be placed with the deeper frog uppermost.

Concrete bricks to BS 6073 should have a crushing strength of not less than 20 N/mm^2 for surface water drainage. Special purpose concrete bricks having a minimum strength of 40 N/mm^2 and a minimum cement content of 350 kg/m^3 should be used for foul drainage and for situations where improved durability is required.

5.7.4 Blocks. Concrete blocks for surface water drainage should comply with BS 6073 and have a density of not less than 1500 kg/m^3 . Manufacturers' advice should be obtained for the suitability of other blocks.

5.7.5 Granular material for bedding. Granular material for use for bedding pipes should comply with one of the requirements set out below. The greater the proportion of fines in the material the greater is the care needed in compaction.

a) Nominal single sized aggregate to Table 4 of BS 882:1983 as follows:

DN 100	10 mm size;
DN 150	10 mm or 14 mm size;
DN 200 and above	10 mm, 14 mm or 20 mm size.

b) Graded aggregate to Table 4 of BS 882:1983 as follows:

DN 150 pipes	graded 14 mm to 5 mm;
DN 200 pipes and above	graded 20 mm to 5 mm; or graded 14 mm to 5 mm.

c) Granular material having a compaction fraction value not greater than 0.3 when tested in accordance with Appendix D. Particle size should not exceed 20 mm.

5.7.6 Backfill material

5.7.6.1 Selected material. Selected material from a trench can be used as side fill for rigid pipes above the bedding, or for the layer directly above the pipes for rigid and flexible pipes, provided that it is readily compactible. It should exclude stones retained on a 40 mm sieve, hard lumps of clay retained on a 100 mm sieve, timber, frozen material and vegetable and foreign matter. Cohesive soil that has dried out on a spoil heap may not be readily compactible and is not suitable.

5.7.6.2 General backfill. Normally the excavated material from the trench will be suitable for backfill above the selected material. Boulders, lumps of concrete, timber and vegetable matter should be excluded.

5.7.6.3 Lean mix concrete. If the use of lean mix concrete for backfill is contemplated the following factors should be considered.

- The concrete mix should be no richer than 1 in 18. Solid, high strength concrete could transmit the full traffic impact load directly to a pipe, irrespective of the depth of the pipe.
- The sides of the trench will tend to consolidate more readily than the concrete, and this could result in a "hump" in the road surface.
- Any other services crossing the trench will be affected by the differential settlement of the fill and the sides of the trench.
- Any subsequent excavation involving removal of concrete would be more difficult than would that of selected backfill.

5.7.6.4 Fill for ductile iron pipes. For ductile iron pipes it is usual to use tamped excavated natural material for the side fill. In bad ground, or where the fill contains large stones or lumps of cohesive material a suitable bedding material should be imported. The excavated or imported material should pass through a 75 mm sieve and should be free from vegetable matter, builders' rubbish, domestic refuse, metal, timber, etc.

5.7.7 Sealing rings. Sealing rings should be made from natural or synthetic rubber complying with BS 2494.

5.7.8 Solvent cements. Solvent cements should comply with either BS 6209 for non pressure pipework or BS 4346-3 for pressure pipework.

Precautions in the use of solvent cements for jointing uPVC drainage pipes can vary for each type of solvent or solvent mixture used in the manufacture of the solvent cement. Some solvents are flammable, whilst others are toxic. For the safe use of solvent cements the manufacturer's data safety sheet should be consulted and relevant precautions taken before the product is used. Where these solvent cements are used in confined spaces the associated handling risks are increased and more specific instructions may have to be obtained from the manufacturer before use. Further advice on this latter aspect can be obtained from HM Inspectors of Factories situated in Area Offices or from HSE Guidance Note GS5 [3] purchaseable from HMSO or through booksellers.

Section 3. Design

6 General design considerations

6.1 Introduction

A drainage system should be designed, installed and maintained so as to convey and discharge its contents without causing a nuisance or danger to health, arising from leakage, blockage or surcharge.

It is essential that early consultation should take place between architect and designer(s) of the engineering services. This should commence at site acquisition stage and continue thereafter to achieve whole-life economy of operation.

There may be technical and economic advantages in providing a drainage system to serve more than one property but such an arrangement may cause difficulties in conveyancing or appointment of maintenance costs. Designers should consider this when preparing drainage layouts.

6.2 Layout

Access should be provided at all bends and junctions. Where a bend external to an inspection chamber or manhole is unavoidable, it should be adjacent and should provide a deviation of not more than 45°. A bend receiving a drop-pipe, a discharge stack or the outfall from a drainage appliance may deviate up to 90°.

Bends, particularly in the smaller diameter pipes, should have a long rather than a short radius and in any case this should be sufficiently long to enable access for cleaning by the usual methods.

Inspection chambers and manholes should be sited so as to avoid the need for acute changes in direction of flow from branch drains (see 7.6).

The routes selected should make full use of the natural slopes of ground or any adjustments thereto, so as to achieve design gradients with minimum excavation.

Common trenches for foul and surface water drains may prove economical in excavation. However, care is needed to ensure the stability of the shallower pipes and the spacing of pipelines should be adequate for the connections, including those which may be needed in the future. When deciding on trench arrangements the primary consideration, as in every aspect of the design process, should be the hydraulic effectiveness of the system.

The layout will be influenced by other factors such as:

- a) site conditions, retained features and existing services;
- b) availability of suitable sewers or outfalls;
- c) layout of building(s); disposition of discharge stacks and rainwater pipes; appliances located on levels necessitating direct connections to drains;

- d) user-pattern of building(s) served;
- e) planning and coordination of services;
- f) practical aspects of excavation for building foundations, working space and adequate protection and support of drainage;
- g) stability of the building during and following construction of the drainage;
- h) density of site development;
- i) provision for future development;
- j) connections to or from existing services which are to be retained;
- k) provision for phased construction and occupation;
- l) feasibility of avoiding areas where the ground contains or is likely to contain tree roots.

6.3 Pipe sizes

A foul drain should be of nominal size not less than DN 100 (see clause 7). A surface water drain should be of nominal size not less than DN 75

(see clause 8). In certain cases a connection to a drain may be of smaller nominal size to suit the nature and volume of flow from a single appliance.

There may be situations where, for hydraulic reasons, a discharge pipe, designed in accordance with BS 5572, may need to be continued below ground without increase in bore to a position in a drainage system where the flow will prevent undesirable deposition of solids. Such a pipe should be laid direct to an inspection chamber or manhole without change of line or gradient.

6.4 Pipe gradients

The choice of gradient should be such as to maintain self-cleansing velocity under normal discharge conditions (see 7.4.4.4).

6.5 Drains laid outside buildings

For housing and small structures it is preferable for drains to be laid outside where provision can be made for ready detection of blockages and their removal. Pipework laid under the buildings should then be limited to short branches.

A drain trench should not impair the stability of a building. When drains are laid parallel to the foundation, care should be taken that the foundations are not undermined (see Figure 9).

Where the horizontal distance between the drain trench and the foundation is less than the depth from the underside of the foundation to the invert of the trench, the sides of the trench should be shored with members of sufficient strength to resist any horizontal or vertical movement of the foundation. This shoring is additional to the statutory requirements for the sides to be supported where persons are required to work in trenches with a depth greater than 1.2 m. Careful consideration should be given before removing this shoring where it is set below the underside of the foundation and the merit of leaving it permanently in place to minimize ground relaxation should be recognized.

Trenches adjacent to load bearing walls within 1 m of the foundation of the wall should be filled with concrete to at least the level of the underside of the foundation. For distances greater than 1 m the concrete fill should be to a level below the underside of the foundation equal to the distance from it to the nearside of the trench, less 150 mm.

6.6 Pipelines under and through structures

Drains should be laid outside buildings wherever practicable. Branch drains from stacks fixed internally and from appliances make some pipework under building unavoidable.

A building designed with central core services and/or strict site limitations may require most, if not all of the drainage to be within or below the building.

Where the routing of drains below or through a building or structure is contemplated it is essential to consider the effects of differential settlement between the building or structure and the drain.

Frequently the only feasible arrangement for large buildings is for the drains to be laid in the ground under the lowest floor or in the underfloor ducts²⁾. Perforation of slabs and retaining walls in contact with the ground should be kept to the minimum so as to reduce the risk of subsoil water seeping into the building around the pipes.

It may be difficult to provide external overflow points, such as open gullies, at suitable levels to give warning of blockage. Surcharge may then cause flooding within the building and suitable and sufficient access is, therefore, essential to enable maintenance to be carried out speedily without causing nuisance or risk of injury to health. Surcharge-warning devices can be provided in appropriate locations where surcharge might result in flooding of critical areas within a building.

6.7 Differential movement

Differential movement in a drain will occur when there is a change in either loading conditions or in the mode of support between successive pipes. Inspection chambers, manholes and other structures generally will be subject to settlement different from that of the pipes associated with them.

Differential settlement can be accommodated by means of flexible joints. The risk of shear fracture is considerably reduced by the provision of a flexible joint located as close as practicable to the face of the structure. The length of the next ("rocker") pipe should not exceed 0.6 m. Where considerable differential settlement is anticipated several "rocker" pipes should be laid, and the gradient should if necessary be increased locally to reduce the likelihood of a back fall developing.

Where it is not necessary for a pipe to be built into a structure, the effects of differential movement may be overcome by the provision of a lintel, relieving arch or sleeve leaving a gap of not less than 50 mm around the pipe. Effective means should be adopted to prevent the entry of gravel, rodents or gas. The designer should take due note of the proximity of underground gas services (see Department of Energy report on gas explosions [4]).

6.8 Ventilation of drains

A free passage of air should be maintained through the system. The achievement of this may affect the layout (see 7.10, 8.13 and 9.9).

6.9 Disused drains

Existing drains which are or will be disused when superseded by new installations should be traced, grubbed up and removed. Where this is impracticable they should be filled with suitable material, e.g. weak concrete, cement grout or similar material to prevent their collapse or, in appropriate circumstances, effectively sealed against ingress of water and vermin, e.g. by sealing all open ends with slates set in cement mortar or by plugs of concrete.

Any drain which, although apparently disused, shows signs of flow should be investigated to establish its origin and authenticity. Arrangements should be made for its diversion or connection to the new system as appropriate.

²⁾ Pipework suspended in basements or similar situations is not covered by this code and reference should be made to BS 5572.

7 Foul drainage

7.1 Drainage to a sewerage system

The outfall of a foul water drainage system should discharge into a foul water or combined sewer, but where such a sewer is not conveniently available and cannot economically be extended to a site other methods of foul water disposal will be necessary, either to treatment or to cesspool. The drainage in these cases should be designed on the separate system.

7.2 Treatment

Where it is necessary to provide sewage treatment facilities the recommendations of BS 6297 should be followed in consultation with the water authority.

7.3 Cesspools

Where an appropriate sewer is not available and sewage treatment is impracticable, provision for storage in a cesspool may be necessary. It should be located where satisfactory arrangements can be made for emptying. Technical advice and guidance on the design of cesspools is given in BS 6297.

Cesspools are not permitted in Scotland.

7.4 Hydraulic design of foul drains

7.4.1 General. In an area sewered on the separate system, all rain and surface water should be excluded from the foul drains. In an area sewered on the partially separate system, where this system is to be used for building drainage, the discharge of rain and surface water into the foul drains should not exceed the proportional quantity allowed for in the overall design of the foul sewers, unless agreed with the drainage authority.

If the area is sewered on the combined system, and all new buildings are to be similarly served, the drains should provide capacity for foul and surface water flows.

7.4.2 Basic principles. Flow in foul drains is intermittent even when serving large numbers of appliances. The discharge flow in a branch drain is normally of a wave form, close to the point of connection of a discharge stack, or an appliance, especially a WC. As the wave travels along the drain its velocity and depth decrease, the attenuation depending on the volume of flow, the gradient, bore, hydraulic roughness of the drain and the presence of fittings. It may also be affected by simultaneous discharges from other appliances connected to the system.

The method given in this code for determining drain size and gradient has been found in practice to result in a reliable and economical system, although it does not exactly reflect the above flow conditions. Probability theory is used to estimate the maximum peak flow rate from appliances, and flow through the drain is assumed to be steady, without attenuation. This ensures that the pipe sizes are adequate at positions of maximum flow depth. Some oversizing downstream of connections in systems with long pipe runs may result, but is usually acceptable in that it provides a factor of safety and may enable future connections to be made without causing surcharge.

7.4.3 Determination of flow

7.4.3.1 General. When assessing probability of use factors and consequential peak flow rates in a foul drain the following should be considered:

- a) the number and type of appliances to be connected;
- b) the rate of discharge from each appliance (L/s);
- c) the average duration of discharge from each appliance (t in s);
- d) the likely use interval of each appliance (T in s);
- e) an acceptable criterion of satisfactory service (see Appendix C).

Table 4 shows typical data for commonly used appliances. The same values are used in BS 5572.

7.4.3.2 Calculation for groups of similar appliances. One simple method of estimating peak flows for drains serving only one type of appliance is based on the probability method referred to in Appendix C. From items c) and d) in 7.4.3.1 a probability of

discharge factor $P \left(P = \frac{t}{T} \right)$ can be found. The

probability of discharge graph given in Figure 1 indicates the probable number of appliances in simultaneous use within a group.

Example: Given a group of 20 WCs in congested use ($P = 0.017$ from Table 4) the graph given in Figure 1 shows that three could be discharged simultaneously, giving a maximum flow rate of $3 \times 2.3 \text{ L/s} = 6.9 \text{ L/s}$.

This method should not be used for groups of mixed appliances because it can lead to unacceptable oversizing of pipes.

7.4.3.3 Calculation for groups of mixed appliances. The probability theory referred to in 7.4.3.2 is also used in the discharge unit method, for the calculations of flow in drains serving mixed appliances. Discharge units are so chosen that the relative load-producing effect of appliances can be expressed as multiples of the units. The discharge unit rating of an appliance depends on its rate and duration of discharge, on the interval between discharges and on the chosen “criterion of satisfactory service”³⁾. It is not a simple multiple of a rate of flow.

Discharge unit values for sanitary appliances in common use are given in Table 4. For other appliances the discharge unit value for each should be deduced from the data given in Table 4 for an appliance with the same trap diameter, and duration and rate of discharge.

Table 4 — Flow rates, probability of discharge factors and discharge unit ratings

Appliances	Capacity	Discharge data		Recurrence use interval (frequency of use), T	Probability of discharge, P $P = \frac{t}{T}$	Discharge units
		Flow rate	Duration, t			
WC (9 L, high level cistern)	L 9	L/s 2.3	s 5	s ^a 1 200 600 300	0.004 0.008 0.017	7 ^b 14 28
Washbasin (32 mm branch discharge pipe)	6	0.6	10	1 200 600 300	0.008 0.017 0.033	1 ^b 3 6
Sink (40 mm branch discharge pipe)	23	0.9	25	1 200 600 300	0.021 0.042 0.083	6 ^c 14 27
Bath (40 mm branch discharge pipe)	80	1.1	75	4 500 (domestic) 1 800	0.017 0.042	7 ^c 18
Automatic washing machine	180	0.7	300	15 000	0.020	4
Shower	—	0.1	—	—	—	Use flow rate
Spray tap	—	0.06	—	—	—	Use flow rate
Urinal (per stall, automatic flushing)	4.5	0.15	30	1 200 900	0.025 0.033	0.3

^a A use interval or recurrent interval (frequency of use) of 1 200 s corresponds to domestic use; 600 s to commercial use; 300 s to congested use such as in public toilets, schools and factories.

^b In domestic installations, the highest loading occurs during the morning peak period and is made up of the discharges from WCs, basins, and sinks. For this reason, a dwelling is usually allotted a fixed number of discharge units for a group consisting of one each of these appliances. In this code, 14 discharge units per dwelling is assumed (see BS 5572).

^c Some proportion of the total number of appliances may be assumed to be in simultaneous operation if considered appropriate.

³⁾ The “criterion of satisfactory service” referred to in this code is 99.5 % and is defined as the percentage of time that the design discharge flow loading will not be exceeded. A graph, based on this figure, showing the number of appliances likely to be in simultaneous use for a given total is shown in Figure 1, for different values of appliance probability of discharge (P) figures.

The discharge unit values of all the appliances contributing to flow in the drain should be added, and the equivalent peak rate in L/s for this total obtained from Figure 2. When the drain carries continuous flows from other sources, their rates can be added to the value obtained from Figure 2.

7.4.4 Determination of pipe size and gradient

7.4.4.1 General. Figure 3 shows the discharge capacities of drains, from 75 mm to 300 mm diameter, when flowing full, and at 0.75 and 0.67 proportional depth. Using Figure 3 and the likely peak flow rate, the designer should select a pipe diameter and gradient taking account of the factors in 7.4.4.2 to 7.4.4.3.

The design curves in Figure 3 are based on a hydraulic roughness of 0.6 mm as defined for the Colebrook-White equation. This roughness should be suitable for intermittently used drains of all pipe materials. However, drains subject to continuous flow, sometimes full, should be designed using a roughness of 1.5 mm (see Figure 4)⁴⁾.

7.4.4.2 Design for minimum blockage. Blockages may occur because of misuse but the risk of recurring blockages during normal use can be minimized by ensuring a high standard of drain and manhole construction throughout the system and that pipes are not unacceptably oversized.

7.4.4.3 Choice of pipe size and depth of flow. Foul drains should be of minimum size DN 100, but where waste water only is conveyed DN 75 is considered acceptable⁵⁾.

For foul drains, the size of the pipe and the gradient (see 7.4.4.4) at which it is to be laid should be so chosen that at peak flow the risk of induced trap siphonage is minimized by ensuring adequate air movement in the drain. This is usually achieved by not exceeding a proportional depth of 0.75 (see also 7.10).

7.4.4.4 Choice of gradients. Choice of gradients should be such as to maintain self-cleansing velocity under normal discharge conditions.

To achieve a satisfactory installation, diameter and gradient should be adequate for the maximum flow and competent supervision should be provided to ensure a high standard of pipe quality, laying, jointing and workmanship. This is particularly important when pipes are laid to flat gradients.

The following guidelines on gradients should be observed.

- a) For flows of less than 1 L/s, pipes not exceeding 100 mm nominal bore at gradients not flatter than 1 : 40 have proved satisfactory.
- b) Where the peak flow is more than 1 L/s, a 100 mm nominal bore pipe may be laid at a gradient not flatter than 1 : 80, provided that at least one WC is connected.
- c) 150 mm nominal bore pipe may be laid at a gradient not flatter than 1 : 150, provided that at least five WCs are connected.
- d) Experience has shown that for gradients flatter than those given in items a) to c), a high standard of design and workmanship is necessary if blockages are to be minimized. Where this has been achieved, gradients of 1 : 130 for 100 mm nominal bore pipes and 1 : 200 for 150 mm nominal bore pipes have been used successfully.

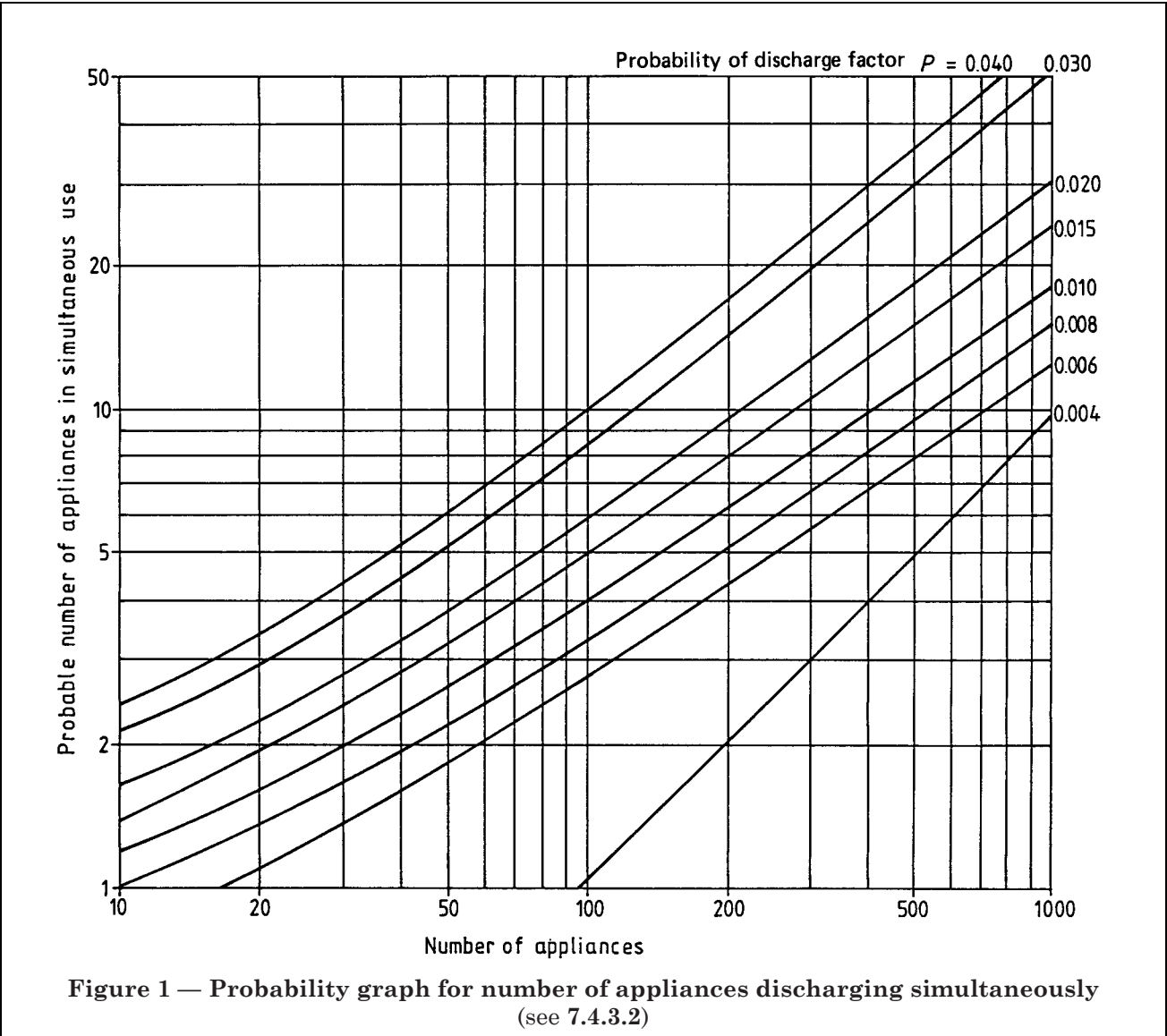
Where the available fall is less than that necessary to achieve the recommended gradient, increasing the pipe diameter particularly at low flows is not a satisfactory solution. It will lead to a reduction in velocity and depth of flow and an increase in the tendency for deposits to accumulate in the pipes.

Where it is expected that a drain may be affected by settlement, the selected gradient should be such as to ensure that a satisfactory fall will be maintained.

Recent research has shown that high velocities of sewage flow arising from steep gradients do not cause increased erosion of pipes or deposition of solids. In such situations drains should be laid at gradients which are the most economical in excavation and cost. High velocities can, however, cause excessive turbulence at bends and manholes and lead to fouling. Where this occurs it can be mitigated, for example by reducing the arc in which fouling can occur by providing an access cover at pipe level.

⁴⁾ See "Tables for the hydraulic design of pipes" (metric edition) (Hydraulics Research Station HMSO 1982) [5]. For further information on on-going research, reference should be made to Water Research Centre.

⁵⁾ There may be special bore requirements, e.g. for hospitals and some industrial discharges.



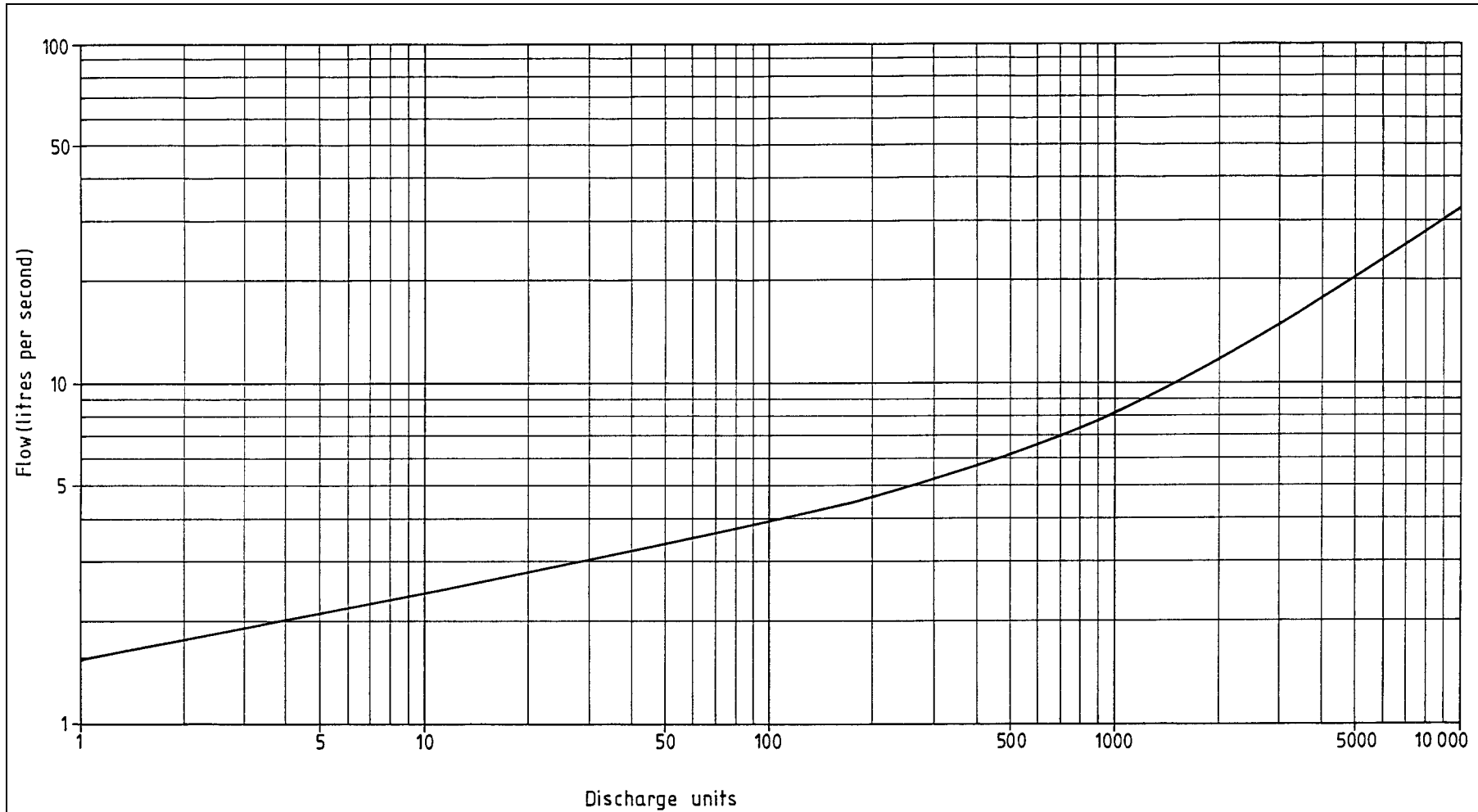


Figure 2 — Design flows for foul drains: conversion of discharge units to flow rates (see 7.4.3.3)

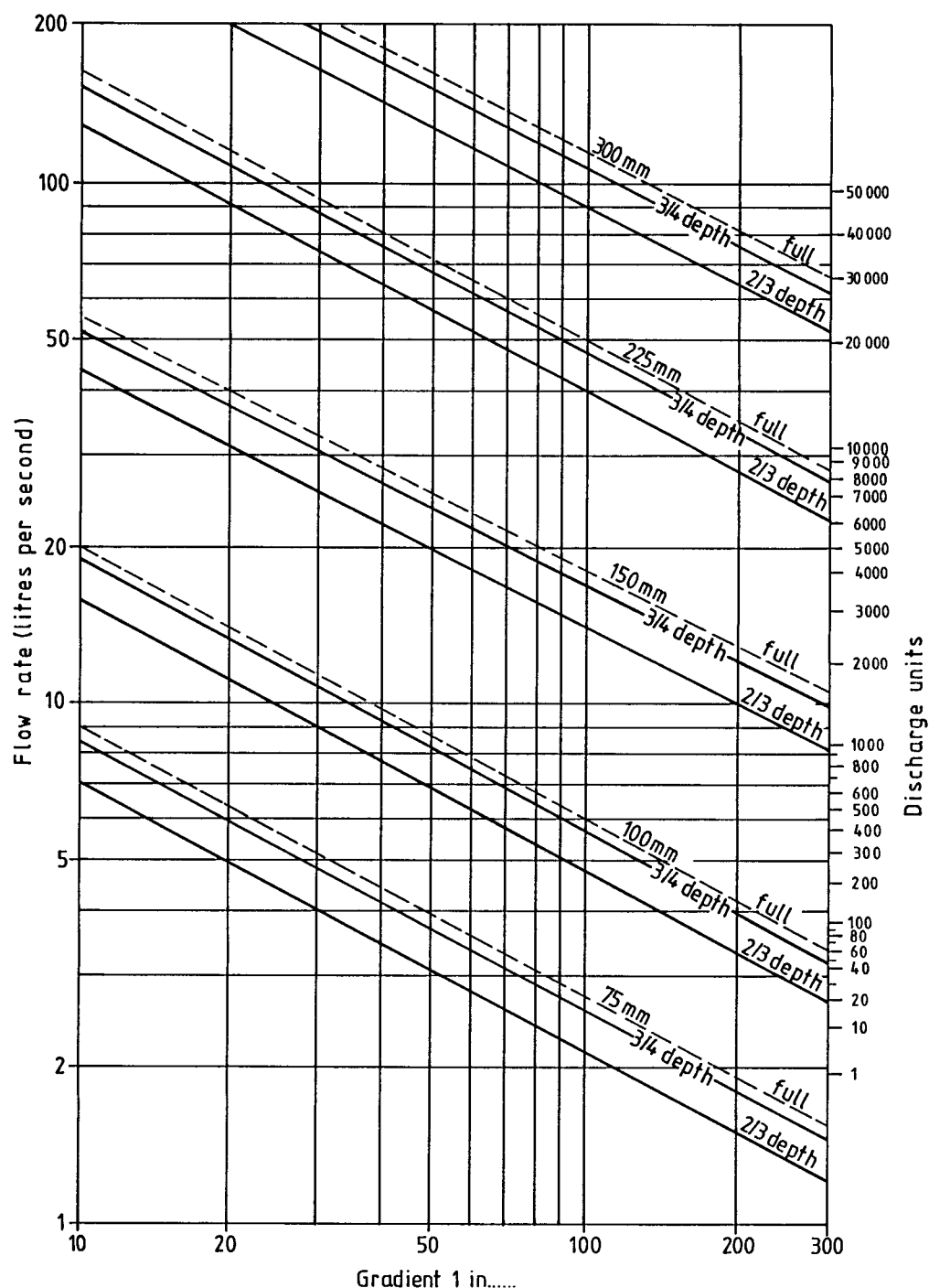


Figure 3 — Discharge capacities of drains running full, $\frac{3}{4}$ and $\frac{2}{3}$ proportional depth: used pipes in good condition (hydraulic roughness, $k = 0.6$ mm)