British Standard

BRITISH STANDARD

BS 5911-100: 1988

Reprinted, incorporating Amendment Nos. 1 and 2

Precast concrete pipes, fittings and ancillary products —

Part 100: Specification for unreinforced and reinforced pipes and fittings with flexible joints

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement, Gypsum, Aggregates and Quarry Products Standards Committee (CAB/-) to Technical Committee CAB/12, upon which the following bodies were represented:

Association of Consulting Engineers
Association of Metropolitan Authorities
British Precast Concrete Federation Ltd.
Cement and Concrete Association
Cement Makers' Federation
Concrete Pipe Association
Concrete Society
County Surveyor's Society
Department of the Environment (Property Services Agency)
Department of Transport (Highways)
Federation of Civil Engineeeing Contractors
Glassfibre Reinforced Cement Association
Institution of Civil Engineers
Institution of Highways and Transportation
Institution of Public Health Engineers
Institution of Water and Environmental Management
Ministry of Agriculture, Fisheries and Food
Sand and Gravel Association Limited
Water Authorities Association

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6269	December 1989	
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Contents

Foreword

This revision of those clauses of BS 5911-1 dealing with pipes, bends and junctions has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee.

The opportunity has been taken to revise the Part numbering system for BS 5911 and this Part becomes Part 100. The clauses on manholes and soakaways in Part 1 have been revised to from the subject of a new Part, Part 200[1)]. When Part 200 is published, BS 5911-1 will be withdrawn. Other types of precast concrete pipe and fittings will be covered by Part 101 onwards, and other ancillary concrete products by Part 201, etc.

The revision incorporates all previously published amendments together with additional material to improve the meaning and interpretation of some of the original clauses, as for example expanding the requirements relating to finish and dealing with the use of adhesives. At the same time a bending moment resistance test for pipes has been introduced.

This Part of BS 5911 is a specification incorporating tests, on pipes in manufacturers' works or in testing stations, that relate to performance of buried pipelines. The criteria are intended to ensure that the pipeline will carry sewage or surface water at atmospheric pressure without leaking or suffering structural damage. Pipes conveying sea water, industrial waste, etc. and those to be installed in an environment aggressive to concrete should be the subject of special consideration, for example as regards concrete cover.

In order to pave the way for an orderly transition to the forthcoming harmonized European Standard for concrete pipes, this Part of BS 5911 now provides for the manufacture and supply of units with rationalized metric sizes.

This standard does not include the structural or hydraulic design of the pipeline, its durability under unusual environmental conditions or standards of workmanship and supervision during construction and operation. For guidance on these topics, work on further British Standards is in hand.

For an enquiry or order to be fully understood it is essential that the manufacturer be given the information set out in Appendix A.

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 36, 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.

[1)] In preparation.

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Section 1. General

1 Scope

This Part of BS 5911 specifies requirements and describes methods of test for precast concrete cylindrical pipes, bends and junctions with flexible joints, either unreinforced or reinforced with steel, intended to be used for the conveyance, under atmospheric pressure, of sewage or surface water, and for the construction of culverts. Requirements are given for materials, dimensions and inspection procedures.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 5911 the following definitions apply.

2.1
unit

a pipe, bend or junction

2.2
unreinforced concrete pipe

a hollow cylinder manufactured from concrete, cast as one piece and of uniform cross section throughout its length, except at the joint profile

NOTE The inclusion of reinforcement solely for handling purposes does not exclude a pipe from this definition.

2.3
reinforced concrete pipe

a pipe, as defined in **2.2**, but reinforced with one or more prefabricated steel cages or hoops suitably positioned to resist tensile stresses imposed by the specified test loads

2.4
nominal size (DN)

a numerical designation of the bore of a unit, which is a convenient round number approximately equal to the internal diameter in millimetres

2.5
manufacturing diameter

a diameter of a unit that a manufacturer seeks to achieve

2.6
actual diameter

a diameter found by measurement

2.7
effective length

the length of a pipe measured as shown in Figure 1

2.8
characteristic strength of concrete

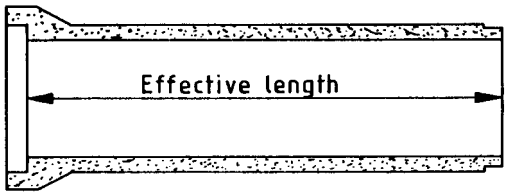
that value of cube strength below which 5 % of all possible strength measurements of the specified concrete are expected to fall

2.9
batch

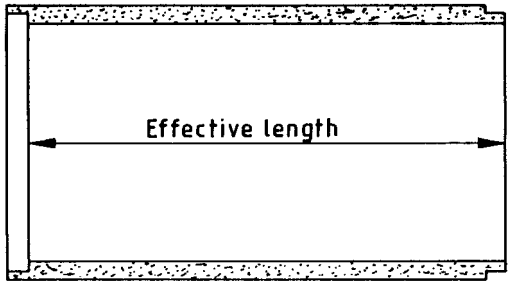
the number of units of a particular specification produced under uniform conditions during a given production period by one particular process

2.10
reinforcement

steel, other than stainless steel, cast within a unit so as to reinforce the concrete or to locate steel for that purpose



(a) Pipe with flexible spigot and socket joint



(b) Pipe with flexible rebated joint

Figure 1 — Effective length of pipes

3 Marking

3.1 Requirements for marking

Each unit shall be clearly marked with the following information:

a) the number of this British Standard, i.e. BS 5911-100[2)];

b) the letter "R", if the unit is reinforced;

c) an indication of the crushing test load(s), which shall consist of either the letters "L", "M" or "H" to denote "light", "medium" or "heavy" class pipes, or, where higher crushing test loads have been specified, the specified works proof and maximum crushing test loads in kilonewtons per metre of effective length (see **20.4.1**);

d) the letter "S", where sulphate-resisting Portland cement has been used;

e) the letter "B", where ground granulated blastfurnace slag (g.g.b.s.) has been used;

f) the letter "P", where pulverized-fuel ash (p.f.a.) has been used;

g) the letter "A", where an admixture has been used;

h) the day, month and year of manufacture;

i) the manufacturer's mark and works identification mark;

j) where tests, as specified in **20.2**, **20.3** or **20.4.2** have been successfully carried out on the unit;

1) the words "Abs", "Hyd" or "Proof" as appropriate,

2) a reference symbol after the words in item 1) to identify the results of the tests in the manufacturer's quality control records.

In addition to the information given in items a) to j), bends shall be marked externally with indelible stripes at least 25 mm wide and 225 mm long, at each end of the two springing lines, to denote the longest and shortest lengths along the outside of the bend.

[2)] Marking BS 5911-100 on or in relation to a product represents a manufacturer's declaration of conformity, ie a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

In addition to the information given in items a) to j), reinforced pipes designed to meet the maximum stresses set up by loading only when tested or laid in a specified position shall be marked "LIFT HERE — TOP" at the crown of the pipe and "INVERT" at the bottom of the pipe.

NOTE Examples of marking

1. "C" "X"

   BS 5911 Pt 100 "R M S A"

   2.5.88

   "Hyd" "Z"

The above marking on a concrete pipe would signify:

"Claimed by manufacturer "C" to have been made at his works "X" and to comply with BS 5911-100; to be reinforced, of class M and made with sulphate-resisting Portland cement; to contain an admixture; to have been made on 2 May 1988, and to have been successfully tested hydrostatically, as specified in **20.3**, with results recorded in the manufacturer's quality control records "Z"."

2. "D" "Y"

   BS 5911 Pt 100 R 240/300

   3.6.88

   "Proof" "T"

The above marking on a concrete pipe would signify:

"Claimed by manufacturer "D" to have been made at his works "Y" and to comply with BS 5911-100; to be reinforced and made to resist works proof and maximum crushing test loads of 240 and 300 kN per metre of effective length, respectively; to have been made on 3 June 1988, and to have been successfully subjected to the works proof load test, as specified in **20.4.2**, with results recorded in the manufacturer's quality control records "T"."

3.2 Method of marking

Units shall be marked with either:

a) indelible paint, applied by stencil brush or spray as soon as possible after removal from the mould; or

b) impressed characters approximately 2 mm deep.

All marks shall be visible and legible. For units of nominal size DN 675 and above, marking shall be on the internal surface of the unit.

Section 2. Materials

4 Cement

The cement shall:

a) be factory-produced by the cement manufacturer and comply with one of the following standards as appropriate;

Type of cement	Standard to be complied with
ordinary and rapid-hardening Portland	BS 12
Portland-blastfurnace	BS 146-2
sulphate-resisting Portland	BS 4027
Portland p.f.a.	BS 6588

or

b) consist of a normal or special combination of cement complying with BS 12 and g.g.b.s or p.f.a. in accordance with the following, to be included as part of the concrete mix by simultaneously combining them with the other concrete materials at the concrete mixer;

Cementitious component other than cement	Standard to be complied with	% by mass of total cementitious content	
		normal	special (additional resistance to sulphate, see note)
g.g.b.s	BS 6699	0 % to 65 %	70 % to 90 %
p.f.a.	BS 3892-1	15 % to 35 %	25 % to 40 %

NOTE The minimum cement content and maximum water/cement ratio specified in **7.1** will ensure that any of the cements listed in item a) or normal combinations of cement complying with BS 12 and g.g.b.s or p.f.a. as specified in item b) will facilitate resistance to sulphate attack equivalent to classes 1 and 2 in Table 6.1 of BS 8110-1:1985. Class 3 resistance will be provided by the use of special combinations of cement complying with BS 12 and g.g.b.s or p.f.a. as specified in item b) or by cement complying with BS 4027; the latter will also facilitate class 4 resistance if the minimum cement content is 370 kg/m^3. The advice of the pipe manufacturer should be sought where class 5 conditions exist.

5 Aggregates

5.1 General

Aggregates shall consist of materials complying with BS 882:1983 except for the grading requirements of clause **5** of that standard.

NOTE The pipe manufacturer may modify the gradings to suit his manufacturing process. (See clause **0** of BS 882:1983.)

5.2 Testing

5.2.1 *Mechanical properties.* The limiting values on the mechanical properties of coarse aggregates shall be either a minimum of 10 % fines value of 100 kN or a maximum aggregate impact value of 30 %. Flakiness index shall be not more than 35.

5.2.2 *Nominal maximum size.* The nominal maximum size of aggregate shall not exceed the least of the following:

a) 20 mm;

b) the concrete cover (see clause **8.2**);

c) one quarter of the minimum thickness of the unit.

6 Other concrete materials

6.1 Water

Water shall be clean and free from harmful matter in such quantities as would affect the properties of the concrete in the plastic or hardened state (see Appendix A of BS 3148:1980).

NOTE As a general rule, potable water, whether treated for distribution through the public supply or untreated, is suitable for making concrete.

6.2 Admixtures

Admixtures shall comply with BS 5075.

NOTE Admixtures, when used (see Appendix A), should not impair the durability of the concrete, nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement.

The chloride ion content of admixtures shall not exceed 2 % by mass of the admixture or 0.03 % by mass of the cement, when used in:

a) any concrete containing reinforcement or other embedded metal; and

b) any concrete made with cement complying with BS 4027.

The manufacturer shall make available details of:

1) the relevant production records;

2) the admixture(s) used;

3) the dosage rate of each admixture;

4) the effect of under- and over-dosing.

7 Concrete mix, casting and finish

7.1 Cement content

The fully compacted concrete shall contain not less than 360 kg of cement (inclusive of any g.g.b.s. or p.f.a.) per cubic metre and shall have a water/cement ratio not greater than 0.45. Where a special combination of cement complying with BS 12 and g.g.b.s or p.f.a. is used (see item b) of clause **4**), the minimum cementitious content shall be increased from 360 kg/m^3 to 380 kg/m^3.

7.2 Chloride content

The total chloride ion content of the concrete mixes shall be as given in Table 1.

Table 1 — Limits of chloride content of concrete

Type of concrete	Maximum total chloride content expressed as a percentage of chloride ion by mass of cement (inclusive of g.g.b.s. or p.f.a. when used)
Heat — cured concrete containing embedded metal	% 0.1
Concrete made with cement complying with BS 4027	0.2
Concrete containing embedded metal and made with cement complying with BS 12, BS 146, or combinations of cement complying with BS 12 and g.g.b.s or p.f.a.	0.4

7.3 Work in cold weather

Concrete, when placed, shall have a temperature of at least 5 °C, which shall be maintained until the concrete is hardened.

It is permissible to heat aggregates and water before mixing, to a temperature not exceeding 60 °C.

Other materials and moulds, if at a temperature below 0 °C, shall not be used.

7.4 Compaction

All units shall be compacted so that, when hardened, they shall be free from honeycombing and from any individual large void (i.e. greater than 6 mm) as defined in **4.4.1** of BS 1881-120:1983. Blistering shall not be regarded as a void.

7.5 Surface finish

7.5.1 *Surface evenness.* When tested in accordance with **B.1**, the internal surface of a pipe shall not have irregularities that cause the central portion of the gauge to touch the pipe.

NOTE For pipes of the smaller nominal sizes, it may prove impracticable to test the central portion of the pipe.

7.5.2 *Surface voids.* Surfaces of units shall be free from voids that, when tested in accordance with **B.2**, permit diametrically opposite points of the rim of the gauge to touch simultaneously the surface of the unit.

Units exhibiting surface voids greater than 12 mm deep shall be deemed not to comply with this standard.

NOTE Voids up to and including 12 mm deep may be made good using material complying with **7.6.1**.

The surface finish of units containing reinforcement shall be in accordance with **8.2**.

7.6 Making good

7.6.1 *Materials.* Materials for making good shall be one of the following.

a) Neat cement grout, with or without the addition of styrene-butadiene rubber (SBR), the type of cement being compatible with that in the unit to be made good.

b) 1 : 3 cement/sand mortar proportioned by mass with or without the addition of SBR. The cement shall be compatible with that in the unit to be made good and the sand shall comply with the requirements for fine aggregate in BS 882 but have a grading such that 100 % of the material passes a 5 mm sieve.

c) A sample of the concrete mix minus the aggregate retained on the 5 mm sieve, with or without the addition of SBR.

d) Epoxy or polyester resin, or polymer latex mortar.

NOTE For guidance on the use of epoxy and polyester resins, see CIRIA Report 69 "Effective use of epoxy and polyester resins in civil engineering structures", published by the Construction Industry Research and Information Association[3]. See also "The Repair of Concrete Structures" published by the Cement and Concrete Association[4] which also deals with polymer latex mortars, and **6.10.5** of BS 8110-1:1985.

7.6.2 *Blistering.* Any blistering shall be made good using material complying with **7.6.1** d).

NOTE Flaking of the surface of a unit would not constitute "blistering".

7.6.3 *Joint surfaces.* Before a unit is tested for compliance it is permissible:

a) subject to **7.4**, to re-work a joint profile for compliance with clause **16** by the application of material complying with **7.6.1** b) or c) to a depth not exceeding 5 mm whilst the concrete is still green, or material complying with **7.6.1** d), or by grinding off;

b) subject to **7.4** and to items 1) and 2) to make good using material complying with **7.6.1** b) or c) any spalling of the arrises of spigots or sockets that has occurred during de-moulding or handling.

1) In any unit the total exposed area of broken concrete shall not exceed $6 \times (DN)$ mm^2 with no individual area greater than $3 \times (DN)$ mm^2.

NOTE For example, the total area for a DN 900 pipe is 5 400 mm^2 with no individual area greater than 2 700 mm^2.

2) No exposed area of broken concrete shall be in contact with both the outer and inner surface of the spigot or socket of a unit.

If material complying with **7.6.1** d) is used, the permissible areas in b) 1) shall be doubled and item b) 2) shall not apply.

7.6.4 *Exposed steel.* Where, on de-moulding, bar steel not forming part of the reinforcement of a unit is visible, or found to be within the concrete cover, it is permissible to remove a maximum of two such pieces each having a length not exceeding half the thickness of the unit and to make good the void(s) with material complying with **7.6.1** d) before the unit is assessed for compliance.

7.6.5 *Rubbing down.* After a unit has been cured and prior to despatch, it is permissible to rub down where necessary to produce a surface finish to comply with **7.5**.

8 Reinforcement

8.1 Materials and arrangement

Reinforcement shall comply with one of the following standards, as appropriate.

Type of reinforcement	Standard to be complied with
Carbon steel bars for the reinforcement of concrete	BS 4449
Cold reduced steel wire for the reinforcement of concrete	BS 4482
Steel fabric for the reinforcement of concrete	BS 4483

[3] Obtainable from CIRIA, 6 Storey's Gate, London SW1P 3AU.

[4] Obtainable from C&CA, Wexham Springs, Slough, Bucks SL3 6PL.

The main reinforcement shall normally be placed in a circular arrangement, in the form of concentric hoops, either hooked, butt welded or lap welded, or in the form of a continuous helix or fabric, suitably welded. Elliptical or any other arrangement of reinforcement is permissible, provided that a lifting hole is cast into the crown of the unit and that the unit is appropriately marked (see clause **3** and **8.3**). Longitudinal bars or wires or any other effective method shall be used to control spacing and shape and to ensure safe handling.

For reinforced pipes, both the barrel and the socket shall be reinforced. It is permissible for such reinforcement to be in separate cages, provided that it complies with **20.6.4**.

The clear space between circumferential bars shall be not less than the nominal maximum size of the coarse aggregate plus 5 mm.

8.2 Protection for reinforcement

The concrete cover over all reinforcement and welded anchorage connectors shall be such that, in any finished unit, it is nowhere less than 12 mm.

An effective means shall be provided for maintaining the reinforcement in position and for ensuring correct cover during manufacture of the unit. Spacers for this purpose shall be of grade 316S31 austenitic stainless steel complying with BS 970-1 or other rustproof material. Units exhibiting rust marks that originate from steel within the unit shall be deemed not to comply with this Part of BS 5911.

Except the exposed section of a cast-in anchorage as described in **8.3.1**, there shall be no steel, other than stainless steel, within the concrete cover. There shall be 25 mm minimum clearance provided between such a cast-in anchorage and any part of the reinforcement by means of welded connectors of steel complying with BS 4449 or BS 4482.

Reinforcement and welded anchorage connectors shall be free from mud, oil, paint, retarders, loose rust, loose mill scale scale, snow, ice, grease or any other substance which can be shown to affect adversely the steel or concrete chemically, or to reduce the bond.

8.3 Lifting facilities

8.3.1 A lifting facility shall be one of the following.

a) A hole through the pipe wall through which a lifting device may be fitted.

b) A recess housing a cast-in steel anchorage complying with BS 4360, hot dip galvanized in accordance with BS 729, and to which a lifting device can be attached. The recess shall be of sufficient depth to enable the anchorage subsequently to be covered to a minimum depth of 12 mm.

NOTE In either a) or b) materials used for making good on site should comply with **7.6.1** b), c) or d). Manufacturers should have available advice on the site work.

8.3.2 A cast-in lifting facility or facilities shall be provided to identify the designed crown of the pipe where elliptical or other non-circular arrangement of main reinforcement is used [see **8.1** and Appendix A g)].

NOTE It is permissible to provide lifting facilities for other pipes [see Appendix A o)].

Section 3. Dimensions and tolerances

9 Nominal size and effective length

9.1 Nominal size (DN)

The nominal sizes (see **2.4**) of units shall be either:

a) those given in column 1 of Table 2; or

b) for units in the ranges given in Table 2A, those at the intervals specified.

Table 2A — Rationalized metric nominal sizes of units [see **9.1** b)]

Nominal size of unit DN	Interval DN
150 to 500	50
500 to 1 000	100
1 000 to 2 200	200
2 200 to 2 800	300

If nominal sizes as specified in item b) are used, the tolerances on diameter and wall thickness shall be those relating to the next higher nominal size given in Table 2.

9.2 Effective length of pipes

The effective length of pipes (see **2.7**) shall be between 0.45 m and 5 m inclusive with a maximum of 3 m for pipes DN 600 or less. The manufacturer shall make available information on the effective lengths of pipes that he is able to supply in a given nominal size named in an enquiry or order (see Appendix A).

NOTE In cases where differential settlement is expected, "rocker pipes" are normally laid as the first pipe after the short section built into the manhole wall. For pipes up to and including DN 450, the effective length of "rocker pipes" will normally be in the range 0.5 m to 0.75 m; for larger pipes the range would be 0.75 m to 1.0 m.

10 Internal manufacturing diameter and actual diameter

The manufacturer shall make available, at the enquiry stage, information on the internal manufacturing diameters (see **2.5**) that he is able to supply (see Appendix A). The internal manufacturing diameter shall not be outside the limits given in column 2 of Table 2.

The actual internal diameter (see **2.6**) shall not deviate from the manufacturing diameter by an amount greater than that given in column 3 of Table 2.

11 External manufacturing diameter

The external manufacturing diameter of the barrel of a unit (see **2.5**) shall be stated by the manufacturer, if so required. (See Appendix A.)

12 Variation in the thickness of wall

The radial thickness of the wall of a unit shall not vary by more than the amount stated in column 4 of Table 2.

13 Squareness of ends

Pipes shall be capable of being jointed in any orientation with their axes coincident within the limits specified in **20.6.2**.

NOTE 1 Squareness of ends of pipes and fittings is significant only as it relates to the performance of the joint assembly.
NOTE 2 A pipeline jointed in accordance with the pipe manufacturer's instructions should provide competently sealed joints when tested in accordance with either BS 8301 or BS 8005.

14 Deviation from straightness

When assessed as described in Appendix C, the pipe shall satisfy the criteria for straightness.

15 Surface cracking

It is permissible for either of the following types of crack to be visible in the surface of the unit:

a) structural cracks that have developed in the tensile zone of reinforced concrete, within the limit specified in **20.4.2.2**, as a result of testing in accordance with Appendix D;

b) crazing within any cement-rich surface layer.

Units exhibiting cracks other than those described in a) and b) shall be deemed not to comply with this Part of BS 5911, whether or not the cracks were caused by testing.

16 Joints

Pipes, bends and the main pipes of junctions shall have flexible joints of the spigot and socket or rebated type. They shall be designed to incorporate an elastomeric ring complying with type D of BS 2494. Joint assemblies shall be tested as specified in **20.6** to the design dimensions recorded by the manufacturer. The profile of a joint shall comply with the design dimensions and tolerances for its size and class.

NOTE For typical joints, see Figure 2.

17 Bends

Bends shall be either cast as one piece, or fabricated using sections of pipe complying with this Part of BS 5911 and bonded with material as specified in **7.6.1** d).

The minimum effective length, measured as shown in Figure 3, shall be as given in Table 3 for the appropriate nominal sizes.

Table 2 — Nominal sizes and tolerances for units [see **9.1** b)]

1	2		3	4
Nominal size of units DN (see **9.1**)	**Limits of internal manufacturing diameter** (see clause **10**)		**Deviation of actual internal diameter from internal manufacturing diameter** (see clause **10**)	**Variation of wall thickness** (see clause **12**)
	Maximum diameter	**Minimum diameter**		
	mm	mm	mm (±)	mm
150	155	150	5	6
225	230	225	5	6
300	305	300	5	6
375	385	365	6	6
450	460	440	6	6
525	535	515	6	6
600	610	590	6	6
675	695	655	6	6
750	770	730	6	6
825	845	805	6	6
900	920	880	6	6
975	995	955	6	6
1 050	1 070	1 030	6	6
1 125	1 145	1 105	6	6
1 200	1 220	1 180	10	10
1 350	1 380	1 330	10	10
1 500	1 530	1 480	10	10
1 650	1 680	1 630	10	10
1 800	1 830	1 780	10	10
1 950	1 980	1 925	16	16
2 100	2 135	2 075	16	16
2 250	2 285	2 225	16	16
2 400	2 435	2 375	16	16
2 550	2 590	2 525	16	16
2 700	2 740	2 675	16	16
2 850	2 890	2 825	16	16
3 000	3 040	2 975	16	16

Table 3 — Minimum effective lengths and typical nominal angles of bends

Nominal size DN	Typical nominal angles	Minimum effective length
	degree	mm
150 to 250	45, 22.5, 11.25	300
300 to 600	45, 22.5, 11.25	450
675 and upwards	22.5, 11.25	500
NOTE 1 Bends may not necessarily have the same load-bearing capacity as the pipes with which they are to be laid. NOTE 2 Bends should have the same manufacturing diameter and wall thickness as the pipes with which they are to be laid.		

18 Junctions

The nominal sizes and dimensions of junctions, as shown in Figure 4, shall be as given in Table 4 and Table 5. In oblique-angled junctions, the length of the oblique branch shall not extend beyond the socket or spigot of the main pipe.

NOTE 1 The main pipes of junctions should have the same manufacturing diameter and wall thickness as the pipeline within which they are to be laid.

NOTE 2 The dimensions and materials of branches should be specified in the purchaser's enquiry or order. (See Appendix A.)

A junction shall be either cast as one piece or built up by inserting a branch pipe in the main concrete pipe. Concrete pipes used for built-up junctions shall comply with this Part of BS 5911.

Table 4 — Right-angled junctions

Nominal size		*A*	*B*
D	D_1		
See **9.1**	To be the same size as *D* or any nominal size less than *D*	Not more than 375 mm	See **9.2**

Table 5 — Oblique-angled junctions

Nominal size		*B*
D	D_1	
See **9.1**	To be the same size as *D* or any nominal size less than *D*	See **9.2**

When built up, the branch shall be secured with adhesive material (see **7.6.1**). Where cement/sand mortar is used it shall comply with **7.6.1** b), the type of cement being consistent with that of the main pipe. Where the branch is built up by using a length of vitrified clay pipe, it shall comply with BS 65.

The internal surface at the intersection of the branch pipe and the main pipe shall have a flush and fair finish.

NOTE Junctions may not necessarily have the same load-bearing capacity as the pipes with which they are to be laid.

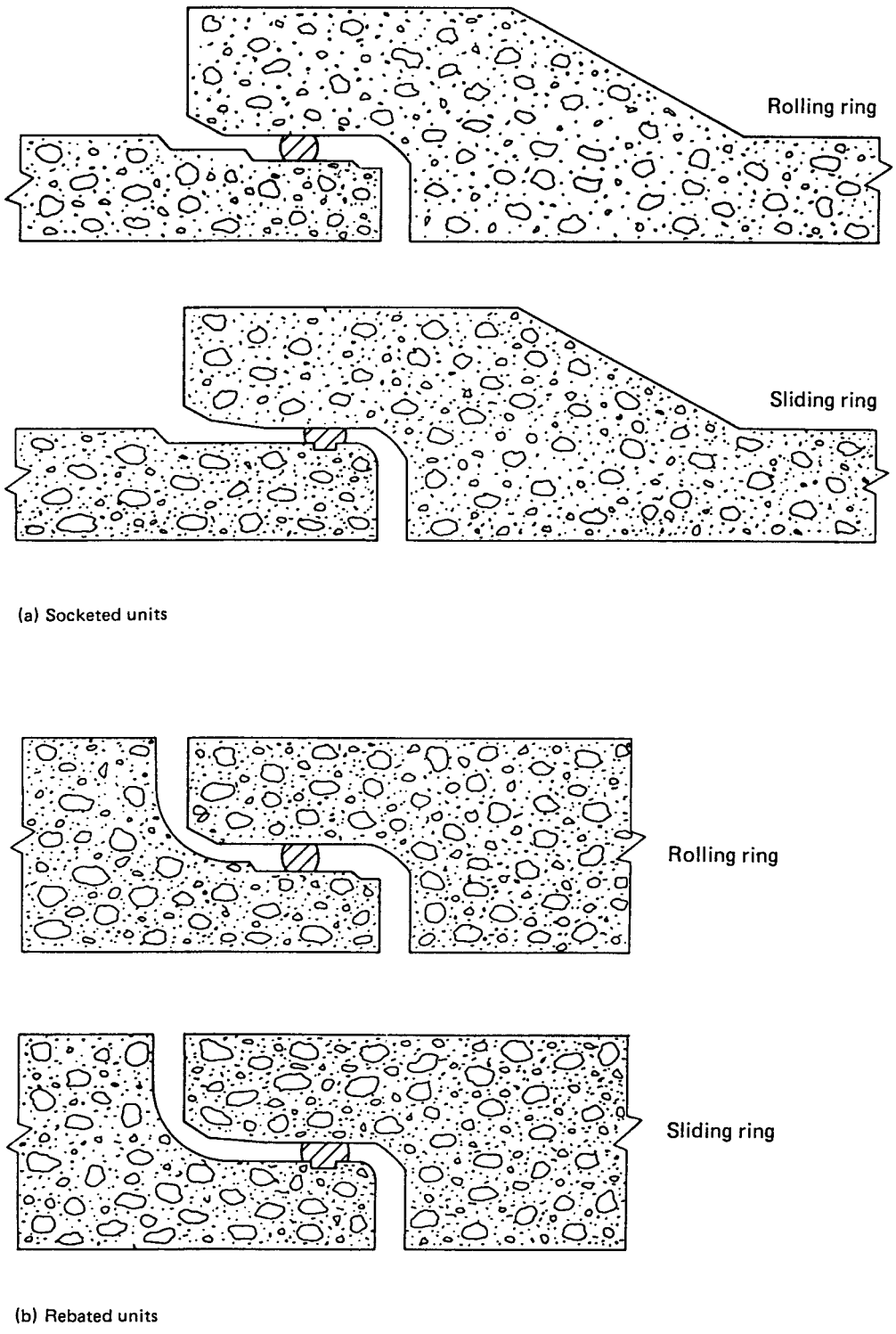


Figure 2 — Typical flexible joints

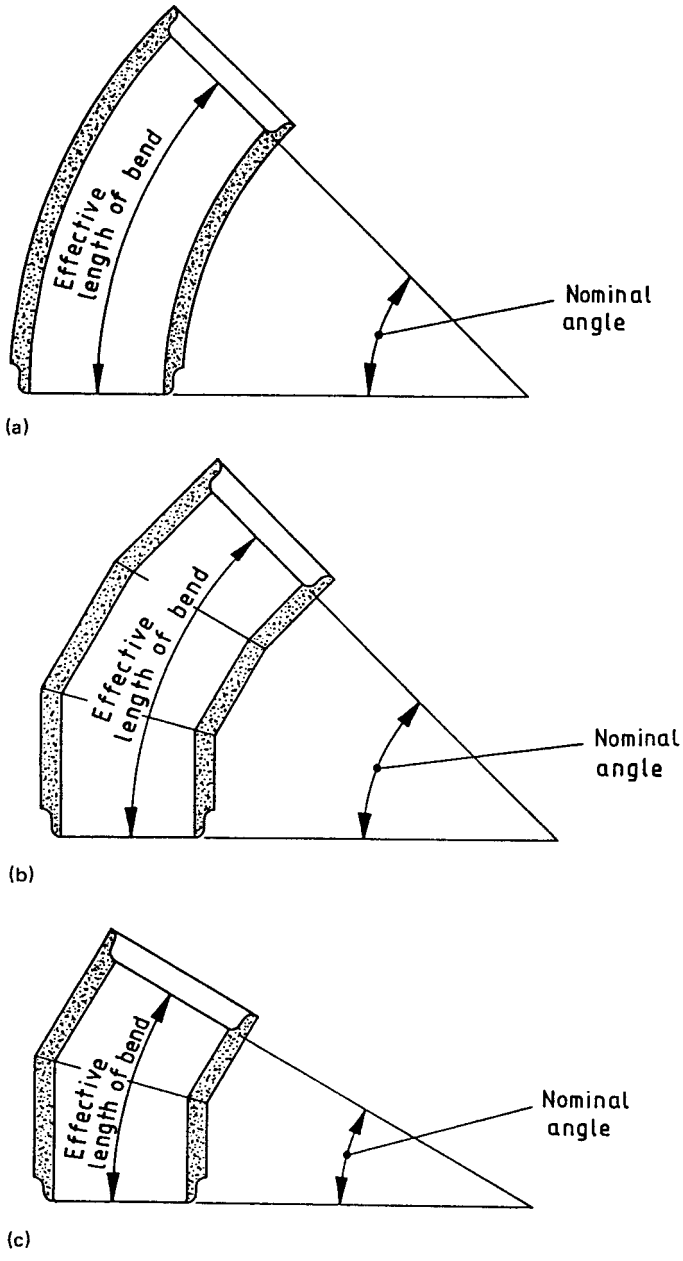
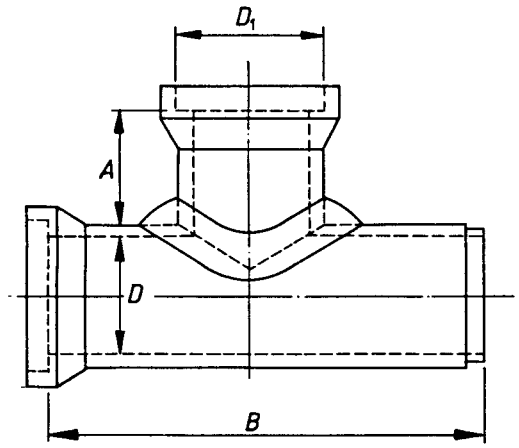
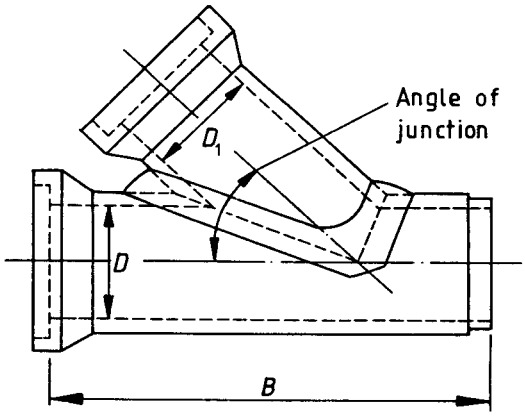


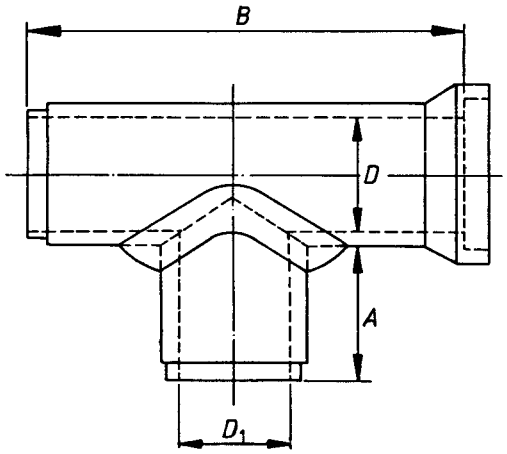
Figure 3 — Typical bends



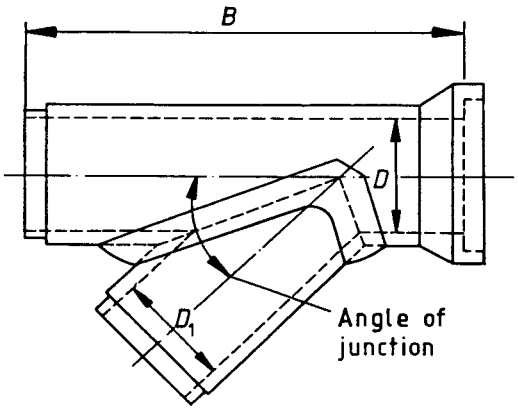
(a) Right-angled socket junction



(c) Oblique-angled socket junction



(b) Right-angled tumbling bay junction



(d) Oblique-angled tumbling bay junction

Figure 4 — Typical junctions

Section 4. Tests

19 General

19.1 Routine and type testing

19.1.1 Units shall comply with the appropriate routine and type test requirements given in this section and summarized in Table 6 and shall be inspected using the procedures specified in section 5.

NOTE Inspection procedures are not given in this Part for isolated batches of units subject to the hydrostatic or works proof load crushing test. See **22.1**.

19.1.2 Type tests shall be carried out to prove the design of a component or assembly. They shall be undertaken wherever there is a change in design, type of material or method of manufacture.

19.1.3 Records of all tests and inspection procedures shall be kept by the manufacturer.

19.2 Test equipment and facilities

The manufacturer shall either:

a) provide in his own works suitable equipment and facilities for sampling and testing the units before delivery; or

b) make arrangements for the provision of suitable equipment and facilities elsewhere for the same purpose.

The manufacturer shall provide certification to show that all test equipment is calibrated at least annually.

19.3 Acceptance of units

Units shall be considered ready for acceptance only after the design has been proven by type tests and the batch of which the units form part has been routinely tested and shown to comply with **20.3** and **20.4.2**.

All units within any batch shall be cured and matured under similar conditions. They shall not be despatched until they are at least 10 days old.

Units cored and treated as specified in **20.2** or reinforced units that have passed the appropriate works proof load test and have not cracked under the load outside the limits specified in **20.4.2.2** shall be marked as specified in clause **3** and shall be taken to comply with this Part of BS 5911 in those respects.

20 Test requirements

20.1 Cube crushing test

For all monolithic bends and junctions cast as one piece, sets of cubes shall be made, cured and tested in accordance with BS 1881-108, BS 1881-111 and BS 1881-116 respectively. When assessed in accordance with BS 5328, the 28-day characteristic strength of concrete having the whole cementitious content in accordance with BS 12 shall be not less than 40 N/mm^2. For other cements the strength shall be not less than 45 N/mm^2.

It is permissible to show compliance with the required 28-day characteristic strength before 28 days have elapsed by testing additional cubes cured and stored under the same regime as the units that they represent.

NOTE Cube tests for the concrete used in pipes, fabricated bends and built-up junctions are not required because the concrete used in the manufacture of these units is generally compacted in quite a different way from the method specified in BS 1881-108.

20.2 Water absorption test

Units, except fabricated bends and built-up junctions, shall be sampled in accordance with **22.3** or **23.4** and prepared and tested in accordance with Appendix E. The increase in the dry mass of a single test piece by absorption of water shall not exceed:

a) 3.6 % after 30 min;

b) 6.5 % after 24 h.

The hole in a unit from which a core specimen has been taken shall be sealed with material complying with **7.6.1** d).

20.3 Hydrostatic test

Pipes of all nominal sizes, bends up to and including DN 300 and junctions with branches up to and including DN 300 off DN 750 shall be sampled and tested in accordance with Appendix F.

Pipes shall withstand an internal hydrostatic pressure of 0.14 N/mm^2 (14 m head) and bends or junctions an internal hydrostatic pressure of 0.07 N/mm^2 (7 m head) for a period of 1 min without cracking, sweating or showing other signs of distress such as leaking or dripping.

NOTE 1 "Sweating" means the appearance of a damp patch on the outside of the unit during the test, due to the internal hydrostatic pressure.

The permeability of concrete is such that, in service, the surface of a unit may be expected to be cold and damp to the touch, but there should be no sign of water passing through the wall.

Prior to testing, a unit shall not be treated with any coating or lining.

Table 6 — Summary of test requirements and inspection procedures

Unit	Nominal size	Test	Requirements given in clause	Test method given in	Required as type test (see **19.1.2**)	Required as routine test	Inspection procedures given in clause
Pipe	All	Surface void	**7.5.2**	Appendix B	—	—	See note 1
	All	Water absorption	**20.2**	Appendix E	√	√	**22.3**
	All	Hydrostatic	**20.3**	Appendix F	√	√	See note 3
	All	Works proof load	**20.4.2**	Appendix D	√	√	See note 3
	All	Maximum load	**20.4.3**	Appendix D	√	√	**22.2**
	All	Cover to reinforcement	**8.2**	Appendix J	√	√	**22.2**
	All	Straightness	**14**	Appendix C	—	—	See note 1
	All	Surface evenness	**7.5.1**	Appendix B	—	—	See note 1
	All	Joint deflection	**20.6.2**	Appendix H	√	—	**22.5**
	All	Joint, straight draw	**20.6.3**	Appendix H	√	—	**22.5**
	All	Joint, shear	**20.6.4**	Appendix H	√	—	**22.5**
	⩽ DN 300	BMR	**20.5**	Appendix G	√	√	**22.4**
Bend (monolithic)	All	Surface void	**7.5.2**	Appendix B	—	—	See note 1
	All	Water absorption	**20.2**	Appendix E	√	√	**23.4**
	All	Cover to reinforcement	**8.2**	Appendix J	√	√	**22.2**
	All	Cube crushing	**20.1**	**20.1**	√	√	**23.2**
	⩽ DN 300	Hydrostatic	**20.3**	Appendix F	√	√	**22.1** and **23.3**
Bend (fabricated)	All	Surface void	**7.5.2**	Appendix B	—	—	See note 1
	All	Water absorption	—	—	√	√	See note 2
	⩽ DN 300	Hydrostatic	**20.3**	Appendix F	√	√	**22.1** and **23.3** See note 3
Junction (cast as one piece)	All	Surface void	**7.5.2**	Appendix B	—	—	See note 1
	All	Water absorption	**20.2**	Appendix E	√	√	**23.4**
	All	Cover to reinforcement	**8.2**	Appendix J	√	√	**22.2**
	All	Cube crushing	**20.1**	**20.1**	√	√	**23.2**
	DN 300 off DN 750	Hydrostatic	**20.3**	Appendix F	√	√	**22.1** and **23.3** See note 3
Junction (built up)	All	Surface void	**7.5.2**	Appendix B	—	—	See note 1
	All	Water absorption	—	—	√	√	See note 2
	All	Cover to reinforcement	**8.2**	Appendix F		√	**22.1** and **23.3** See note 3
	DN 300 off DN 750	Hydrostatic	**20.3**	Appendix J	√ √	√	
Pipe with lifting anchorage	All	Pull-out test	**20.8**	Appendix L	✓	—	See note 1

NOTE 1 These tests are to be carried out as and when required.

NOTE 2 Fabricated bends and built-up junctions are made from sections of pipe and do not require separate testing and inspection.

NOTE 3 Inspection procedures are not given in this Part for isolated batches of units subject to the hydrostatic or works proof load crushing test. See **22.1**.

NOTE 2 The use of a test pressure of 0.14 N/mm^2 for 1 min is to provide a rapid indication of the impermeability of the pipe. The values of internal pressure specified for testing bends and junctions is less than that specified for pipes because these units should be strengthened in service by the surrounding concrete and because of the difficulty of clamping units for the test.

20.4 Crushing tests for pipes

20.4.1 *General.* The maximum and works proof crushing test loads for pipes shall be:

a) those shown in Table 7; or

b) for pipes of nominal size in accordance with item b) of **9.1**, interpolated between the values given in Table 7 for adjacent nominal sizes of the same class; or

c) where stronger pipes are designed and manufactured, appropriate higher loads.

The works proof load for all such pipes shall be taken to be 80 % of the maximum load.

20.4.2 ***Works proof load test***

20.4.2.1 *Unreinforced pipes.* When tested in accordance with Appendix D, an unreinforced pipe shall withstand for at least 1 min the appropriate works proof load specified in **20.4.1** for its size and class.

20.4.2.2 *Reinforced pipes.* When tested in accordance with Appendix D, a reinforced pipe shall withstand for at least 1 min the appropriate works proof load specified in **20.4.1** for its size and class without developing a crack penetrable by a 0.25 mm feeler gauge as described in **D.4**.

Failure shall constitute penetration to a depth of 2 mm on inspection at intervals of 20 mm to 50 mm over a length of 300 mm or more.

NOTE Given the inspection procedures specified in this standard and the minimum cover specified in **8.2** for pipes not exposed to particularly aggressive environments, the permissible crack width of 0.25 mm is consistent with the crack control provisions given in BS 8110-1 and BS 8110-2.

20.4.3 ***Maximum load test***

20.4.3.1 *Unreinforced pipes.* When tested in accordance with Appendix D, an unreinforced pipe shall withstand, without showing signs of distress, the appropriate maximum test load specified in **20.4.1**.

20.4.3.2 *Reinforced pipes.* When tested in accordance with Appendix D, a reinforced pipe shall withstand, with no limit on crack width but without collapse, a load that is not less than the maximum test load specified in **20.4.1**.

20.5 Bending moment resistance (BMR) of pipes

Pipes up to and including DN 300 with effective lengths greater than 1.25 m shall, when tested in accordance with one of the methods described in Appendix G, resist the bending moment appropriate to their size and class, as specified in Table 8, or, where stronger pipes are designed and manufactured (see **20.4.1**) an appropriate higher value.

For pipes of rationalized metric nominal sizes the relevant bending moment shall be interpolated between the values given in Table 8 for adjacent nominal sizes of the same class.

NOTE See Appendix A c).

20.6 Tests for flexible joints

20.6.1 *General.* Type tests for flexible joints shall be carried out on pipes, or parts of pipes, that have been jointed and subjected to internal hydrostatic pressure as described in Appendix F. Where more than one test is done simultaneously all the requirements of each of these tests shall be met.

NOTE The use of a test pressure maintained for 5 min or 10 min is in order to provide an indication of the watertightness of the joint in service.

20.6.2 *Deflection test.* When tested in accordance with **H.1** the pipes, or parts of pipes, that have been jointed shall, without loss of watertightness at the joint, provide angular deflection between the longitudinal axes of the two pipes, measured as shown in Figure 5(a), which is not less than that given in Table 9.

20.6.3 *Straight draw test.* When tested in accordance with **H.2** the pipes, or parts of pipes, that have been jointed shall, without loss of watertightness at the joint, provide a straight draw, measured as shown in Figure 5(b), which is not less than that given in Table 9.

20.6.4 *Shear test.* When tested in accordance with **H.3** the pipes, or parts of pipes, that have been jointed shall, without loss of watertightness at the joint, withstand a test load of 0.025 × (DN) kilonewtons, for nominal sizes up to and including DN 1500, and 37.5 kN for nominal sizes greater than DN 1500 and up to and including DN 3000.

NOTE For example, the test load for a pipe of size DN 1200 should be 0.025 × 1200 = 30 kN.

Table 7 — Crushing test loads

Nominal size of pipe DN	Class L		Class M		Class H	
	Works proof load	Maximum load	Works proof load	Maximum load	Works proof load	Maximum load
	Kilonewtons per metre of effective length					
150	20	25	23	29	—	—
225	20	25	23	29	—	—
300	20	25	23	29	—	—
375	20	25	31	39	36	45
450	20	25	35	44	41	52
525	20	25	38	48	46	58
600	20	25	46	58	54	68
675	20	25	50	63	60	75
750	38	48	53	67	65	81
825	41	52	58	72	69	86
900	46	58	67	84	85	106
975	48	60	72	90	91	114
1 050	51	64	76	95	96	120
1 125	53	67	82	103	106	133
1 200	58	72	87	109	110	138
1 350	63	79	96	120	122	153
1 500	69	87	104	130	132	165
1 650	75	94	116	145	146	183
1 800	82	103	124	155	158	198
1 950	88	110	135	169	169	212
2 100	96	120	146	183	184	230
2 250	102	128	155	194	195	244
2 400	108	135	165	207	210	263
2 550	116	145	177	222	223	279
2 700	124	155	186	233	235	294
2 850	130	163	195	244	251	314
3 000	135	169	207	259	260	326

NOTE 1 Work proof load for each size and class of pipe is 80 % of maximum load rounded off to the nearest kilonewtons per metre of effective length.

NOTE 2 For information on the application of the above pipe crushing test loads to design of pipelines, reference should be made to "Simplified tables of external loads on buried pipelines" (HMSO 1986) and "A guide to design loadings for buried rigid Pipes" (HMSO 1983).

NOTE 3 Pipes of higher crushing strength are available (see **20.4.1**).

Table 8 — Bending moment resistance (BMR)

Nominal size of pipe DN	Class L	Class M
	kN.m	kN.m
150	3.4	4.2
225	8.1	9.3
300	15.9	17.5

20.7 Test for depth of cover to reinforcement

Reinforced units shall be sampled and tested in accordance with Appendix J.

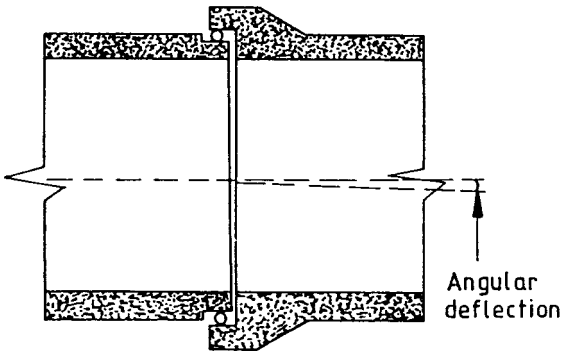
Units that have been successfully tested shall be made good with material complying with **7.6.1** d) before despatch and shall be taken to comply with this Part of BS 5911 in that respect.

20.8 Anchorage pull-out test

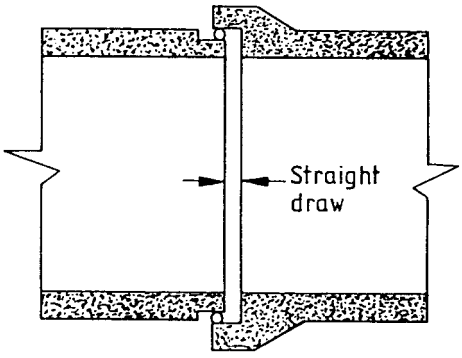
Type tests for pull-out load on cast-in steel anchorages shall be carried out in accordance with Appendix L. When loaded as specified in Appendix L the anchorage shall remain intact and no visible damage caused to either the anchorage or the adjacent concrete.

Table 9 — Minimum angular deflection and straight draw for joints

Nominal size of pipe DN	Minimum angular deflection	Minimum straight draw
	degree	mm
150 to 600	2	20
675 to 1 200	1	20
1 350 to 1 800	0.5	20
Above 1 800	To be stated by the manufacturer	



(a) Angular deflection of joint



(b) Straight draw of joint

Figure 5 — Joint test measurements

Section 5. Inspection procedures

21 Type of inspection and batch size

21.1 Type of inspection

21.1.1 *Normal inspection.* Normal inspection shall be used when a process has been in operation long enough to be in a state of control.

21.1.2 *Tightened inspection.* Tightened inspection shall be used:

a) when inspecting a new product, a redesigned product or a new production line; or

b) when so directed by the switching rules in **21.2**.

21.1.3 *Reduced inspection.* Reduced inspection shall be substituted for normal inspection only when permitted by the switching rules given in **21.2.4**.

21.2 Switching rules

21.2.1 *General.* Changes from one inspection type to another shall be in accordance with the following switching rules. The rules given in **21.2.2**, **21.2.5** and **21.2.6** shall apply in all cases, whereas the rules given in **21.2.3** and **21.2.4** shall apply at the discretion of the manufacturer.

21.2.2 *Normal to tightened inspection.* When using normal inspection, switch to tightened inspection if two in five or less consecutive batches have been rejected.

21.2.3 *Tightened to normal inspection.* When using tightened inspection, switch to normal inspection only when five consecutive batches have been accepted.

21.2.4 ***Normal to reduced inspection (hydrostatic and works proof load crushing test)***

21.2.4.1 When using normal inspection, switch to reduced inspection only if:

a) the last 10 batches (see Table 10) have been subject to normal inspection and have all been accepted; and

b) the total number of defectives in samples taken from the last 10 batches is less than or equal to the number given in Table 10. When double sampling is used, all samples inspected shall be included, i.e. not the first samples only.

21.2.4.2 Where the sample consists of less than 30 units, more batches shall be used, provided that the batches used are the most recent ones in sequence, that they have all been on normal inspection, and that none has been rejected.

NOTE A total of less than 30 units sampled is not sufficient for switching to reduced inspection.

21.2.5 *Reduced to normal inspection (hydrostatic and works proof load crushing test).* When using reduced inspection, switch to normal inspection if:

a) a batch is rejected; or

b) a batch is accepted where the acceptance number given in column 4 (single sampling) or 6 (double sampling) of Table 11 has been exceeded, but the rejection number in column 5 (single sampling) or 7 (double sampling) has not been reached; or

c) production becomes irregular or delayed.

Table 10 — Maximum number of individual defectives in last 10 batches permitted for switching to reduced inspection (hydrostatic and works proof load crushing test)

Number of units sampled from last 10 batches	Total number of defectives in last 10 batches on normal inspection
30 to 79	0
80 to 129	2
130 to 199	4
200 to 319	8
320 to 499	14
500 to 799	25
800 to 1 249	42

NOTE The values in this table are consistent with those in Table VIII of BS 6001-1:1972 for a target acceptable quality level (AQL) of 6.5 %.

21.2.6 *Tightened inspection to stopping production.* When using tightened inspection, stop production if it is not possible to switch to normal inspection
(see **21.2.3**) after 10 consecutive batches.

Investigate the cause of failure and take any necessary remedial action. Resume production using tightened inspection.

21.3 Size of batch

When inspecting units, it is permissible to choose any size of batch (see **2.9**), provided that:

a) the units are in accordance with **19.3**; and

b) where a batch consists of more than 150 units, it is produced within a 24 h period.

22 Inspection procedures for pipes

22.1 Inspection procedure for the hydrostatic or works proof load crushing test

The inspection procedure given in items a) to f) shall be used whenever a regular process is in operation and units subject to the hydrostatic or works proof load crushing test are being produced on a continuing basis.

NOTE The sampling plan in this clause follows BS 6001-1:1972, which is intended primarily to be used for a continuing series of batches and warns that for isolated batches more stringent sampling plans will be required to give the desired protection (see also BS 6000). On that basis, therefore, more stringent inspection criteria should be specified where batches are not to be produced as part of a regular pipe production process.

a) Determine the appropriate inspection type (see **21.1**).

b) Select the batch size (see **21.3**). For the hydrostatic test only, it is permissible to group together pipes of different specifications, provided that all the following conditions are satisfied:

1) all pipes in such a batch are produced by the same manufacturing process;

2) the ratio of the largest to the smallest nominal size in the batch is not greater than 1.5;

3) the production period is not more than one week;

4) the size of the batch does not exceed 150 pipes;

5) any subsequent acceptance or rejection applies to all pipes in the batch.

c) Take a random sample of size as given in column 3 of Table 11 for the appropriate inspection type and size of batch.

d) Subject the sample to the hydrostatic test specified in **20.3** or the works proof load test specified in **20.4.2**.

e) Assess the acceptability of the batch, as follows.

1) For batches of 25 or less (single sampling), if the number of defectives is nil (see "Accept" number in column 4 of Table 11), accept the batch. If the number of defectives is one or more (see "Reject" number in column 5 of Table 11), reject the batch.

2) For batches of 26 or more (double sampling), if the number of defectives is equal to or less than the "Accept" number in column 4 of Table 11, accept the batch, with the exception of any defectives. If the number of defectives is equal to or greater than the "Reject" number in column 5 of Table 11, reject the batch.

However, if the number of defectives is greater than the "Accept" number in column 4 but less than the "Reject" number in column 5, take a second random sample of the same size as the first one. Then if the cumulative number of defectives for both samples is less than the second "Reject" number (column 7), accept the batch, with the exception of any defectives [see also **21.2.5** b)]. If the cumulative number of defectives is equal to or greater than the "Reject" number in column 7, reject the batch.

f) Record the results.

Where a batch has been rejected during the inspection for the hydrostatic test, the manufacturer shall be permitted to test the remaining pipes in that batch, and to claim compliance for those pipes that pass the tests.

Where a batch has been rejected during the inspection for the works proof load crushing test, it is permissible for the remaining pipes in the batch to be reclassified in a lower strength class appropriate to the failure load measured for the pipe that failed the test. In such a case, the marking on the remaining pipes shall be amended accordingly.

22.2 Inspection procedure for the maximum load crushing test and test for depth of cover to reinforcement

When carrying out the maximum load crushing test and the test for depth of cover to reinforcement, the inspection procedure shall be as follows.

a) Select one pipe at random from each 30 pipes of a given specification selected for the works proof load crushing test in accordance with **22.1**, provided that not more than one pipe is selected from consecutive batches comprising a total of 600 pipes or less of the given specification.

If no pipe has been selected during a period of one month, select one pipe of any specification at random from each manufacturing process, provided that the pipes selected within a 12 month period are representative of the full range of nominal sizes produced during that period.

b) Subject the pipe to the maximum crushing test load specified in **20.4.3** and, if reinforced, the depth of cover to reinforcement test specified in **20.7**.

c) If the pipe fails, record the result, discontinue the manufacturing process, investigate the cause of failure and take any necessary remedial action.

d) Restart the process and test the first three pipes made thereafter.

e) If all three pipes pass the test, resume production and inspection, using the tightened rate of inspection for the works proof load test (see **21.1.2**).

However, if any pipe fails, discontinue the manufacturing process and carry out further investigations and remedial action.

f) Repeat d) and e) until satisfactory results have been obtained.

Where a pipe fails the depth of cover to reinforcement test, the batch from which it was selected shall be rejected but it is permissible to subject the remaining pipes in the batch to the test. Only those that pass the test shall be accepted.

Table 11 — Inspection plans for hydrostatic and works proof load crushing tests

1	2	3	4	5	6	7
Inspection type	**Batch size**	**Sample size** (see note 2)	**Accept**	**Reject**	**Accept**	**Reject**
			Numbers of defectives			
Normal	2 to 25	2 (single)	0	1		
	26 to 150	5 (double)	0	2	1	2
	151 to 280	8 (double)	0	3	3	4
	281 to 500	13 (double)	1	4	4	5 } See **21.3** b)
	501 to 1 200	20 (double)	2	5	6	7
Tightened	2 to 25	3 (single)	0	1		
	26 to 150	8 (double)	0	2	1	2
	151 to 280	8 (double)	0	2	1	2
	281 to 500	13 (double)	0	3	3	4 } See **21.3** b)
	501 to 1 200	20 (double)	1	4	4	5
Reduced	2 to 25	2 (single)	0	1		
	26 to 150	2 (double)	0	2	0	2
	151 to 280	3 (double)	0	3	0	4
	281 to 500	5 (double)	0	4	1	5 } See **21.3** b)
	501 to 1 200	8 (double)	0	4	3	6

NOTE 1 The above table follows tables in BS 6001-1:1972 and is consistent with a target acceptable quality level (AQL) of 6.5 % at General Inspection Level 1.

NOTE 2 Sample sizes given in this table are not suitable for assessing compliance with the standard on an isolated batch basis (see **22.1**).

Where a pipe fails the maximum load crushing test, the batch from which it was selected shall be rejected. However, it is permissible for the manufacturer to reclassify the remaining pipes in the batch in a lower strength class appropriate to the failure load measured for the pipe that failed the test. In such a case, the marking on the remaining pipes shall be amended accordingly.

22.3 Inspection procedure for the water absorption test

When carrying out the water absorption test, the following inspection procedure shall be used.

a) From each manufacturing process, select one in 500 or two pipes per week, whichever is the greater, and take specimens as described in Appendix E. Use the same type of specimen for all tests on a given product.

b) Subject the specimens to the water absorption test specified in **20.2**.

c) If the specimens pass the test, accept the pipes in the batch or batches from which they were taken. If any specimen fails, repeat a) and b), using a second sample.

d) If the specimens obtained from the second sample of pipes pass the test, accept the pipes in the batch or batches from which they were taken. However, if any of these specimens fail, proceed as follows.

1) Reject the batch or batches. However, it is permissible to take specimens from all the remaining pipes and subject them to the test. Only those pipes that pass the test shall be accepted.

2) Investigate the cause of failure and take any necessary remedial action.

3) Resume production and increase the rate of inspection to one in 250 or four pipes per week, whichever is the greater.

4) Resume the rate of inspection given in a) only after all samples taken during a production period of five consecutive weeks have passed the test.

22.4 Inspection procedure for bending moment resistance (BMR) test

Each time a pipe in the size range up to and including DN 300 with effective length greater than 1.25 m is selected from a batch for the maximum load test in accordance with **22.2**, select one pipe at random from that batch for the BMR test. If this fails to comply, select three more, and if all pass the test, accept the batch; if one or more fails, reject the batch and stop production until the fault is rectified and the test is successfully completed.

22.5 Inspection procedure for joints (angular deflection, straight draw and shear)

Pipes, or parts of pipes, of two nominal sizes from each of the three ranges up to and including DN 1800 (see Table 9), shall be so selected as to be representative of the range with regard to the rubber joint ring and that part of the joint profile that is effective when jointing. A joint assembly of each of these representative nominal sizes shall be submitted to the tests for deflection, straight draw and shear specified in **20.6**.

For nominal sizes greater than DN 1800, pipes, or parts of pipes, of one representative nominal size shall be selected.

If any of the specified size ranges includes more than one joint ring type or more than one joint profile, i.e. jointing surfaces of differing relative dimensions, separate type tests shall be carried out on representative samples of the differing profiles within that particular size range.

If any joint assembly is subsequently modified by changing any dimension affecting the joint, or if there is any modification of pipe joint ring specification that affects the joint performance, the type tests for the joint assembly shall be repeated.

Once a type test has been used to establish joint criteria, the manufacturer shall keep and make available a list of critical dimensions.

22.6 Inspection procedure for anchorages

Representative pipes with not more than 10 days maturity shall be selected at random with the minimum wall thicknesses and pipe weight with which the anchorage is to be used, and shall be tested in accordance with the type test specified in **20.8**.

23 Inspection procedures for bends and junctions

23.1 General

Unless otherwise specified in **23.2** to **23.4**, inspection procedures for bends and junctions shall be the same as those for pipes given in clause **22**.

NOTE For guidance, see Table 6.

23.2 Inspection procedure for cube crushing test

When carrying out the cube crushing test specified in **20.1**, the inspection procedure for each mix design shall be as follows.

a) Take samples of freshly made concrete at random intervals from not less than 2 % of the total number of batches of concrete. Sampling shall be at a rate of not less than one sample per 50 m^3 of fresh concrete, and in any case not less than one per day.

b) From each sample, make, cure and test a set of cubes as specified in **20.1**.

c) If a series of cube tests show failure to meet the required characteristic strength, adjust the mix design.

23.3 Inspection procedure for hydrostatic test

The inspection procedure shall be the same as that described for pipes in **22.1**, except that a test pressure of 0.07 N/mm^2 at a rate of loading of 0.035 N/mm^2 per 5 s shall be used.

23.4 Inspection procedure for water absorption test

The inspection procedure shall be the same as that described for pipes in **22.3**, except that, under a), it is also permissible to make one test cube to represent 500 units or two test cubes per week, whichever is the greater, as described in Appendix E.

Appendix A Information to be supplied in an enquiry and order

The following particulars cover essential details required by the manufacturer so that an enquiry or order may be fully understood.

a) Quantity and nominal size of units. (See **9.1**.)

b) If any restriction on effective length is to apply. (See **9.2**.)

c) Crushing test loads of units, and whether units are required to be reinforced. (See **20.4**.) If crushing test loads higher than those given in Table 7 are required, the maximum load and, for pipes up to DN 300, the BMR value.

d) The classification of exposure conditions for sulphate attack, if higher than class **2**. (See clause **4**.)

e) If samples of aggregates and/or evidence of satisfactory performance of concrete made with such aggregates are required. (See Appendix K.)

f) If any restriction on admixtures is required. (See **6.2**.)

g) If main reinforcement in a non-circular arrangement is acceptable. (See **8.1**.)

h) If additional concrete cover is required. (See foreword.)

i) If details of internal and external diameter are required. (See clauses **10** and **11**.)

j) Type of bend required. (See clause **17**.)

k) Dimensions and materials of branch pipes for junctions. (See clause **18**.)

l) The number and type of tests to be witnessed and if any additional tests are required. (See Appendix K.)

m) If the products are to be covered by a third party certification scheme. (See Appendix K.)

n) If units subject to the hydrostatic or works proof load crushing test are not to be produced as part of a continuing series of batches, the specified inspection procedures (See **22.1**.)

o) If lifting facilities are required for pipes other than those with main reinforcement in a non-circular arrangement.

Appendix B Methods of assessing surface finish

B.1 Surface evenness

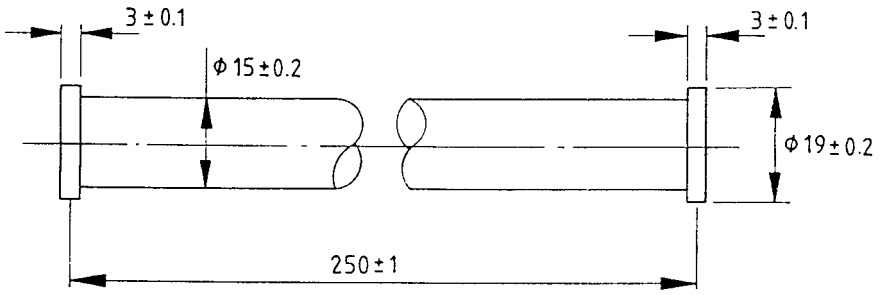
Place the gauge (see Figure 6) in the pipe so that its axis is in the same plane as the longitudinal axis of the pipe.

Roll the gauge around the inside of the pipe, taking care to ensure that its axis remains in the same plane as the pipe's longitudinal axis at all times.

Ascertain that the gauge rolls over any part of the internal surface without the central portion of the gauge contacting the pipe.

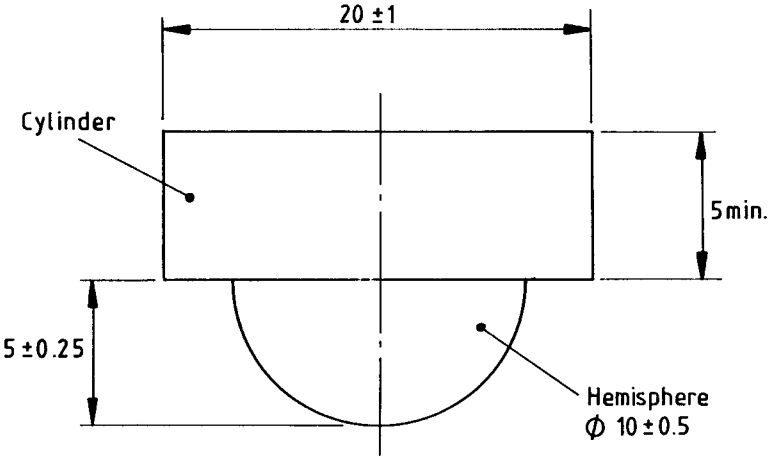
B.2 Surface voids

Apply the ball of the gauge (see Figure 7) to the void and observe whether or not diametrically opposite points in the rim touch the surface of the unit.



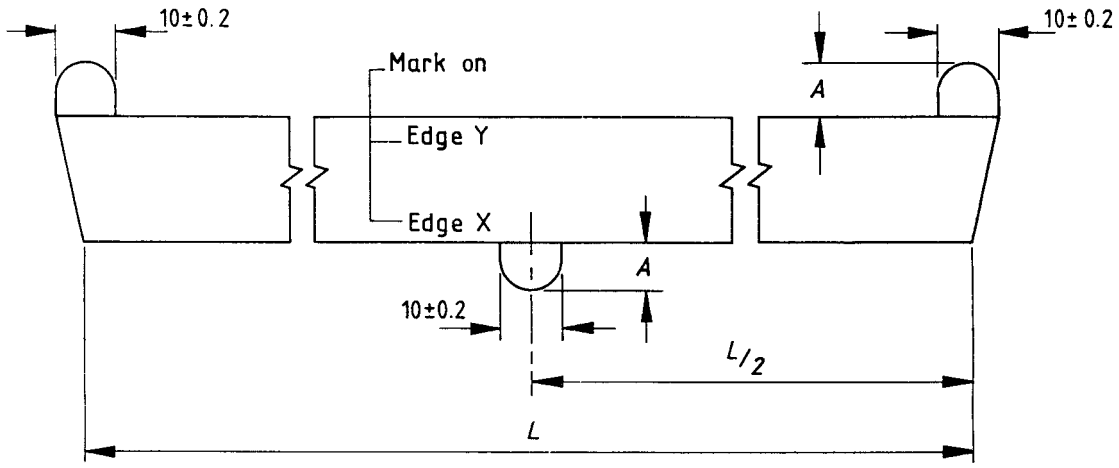
All dimensions are in millimetres.

Figure 6 — Gauge for assessing surface evenness



All dimensions are in millimetres.

Figure 7 — Gauge for assessing surface voids



A = (3.5 X effective length of the pipe in metres) mm ± 5 %

L = (effective length of the pipe – 10) mm (to the nearest mm)

NOTE The studs should be detachable from the basic straightedge to facilitate checking and replacement.
All dimensions are in millimetres.

Figure 8 — Gauge for measuring deviation from straightness

Appendix C Method of assessment of deviation from straightness

Assess the deviation from straightness of pipes in the following manner.

a) Place a rigid straightedge, made into a gauge of the form and dimensions shown in Figure 8 in the bore of the pipe with edge X in contact with the pipe and on a line parallel to the pipe axis. Hold the plane of the gauge in a radial plane.

If both ends of the gauge, wherever so placed, are in contact with the internal surface of the pipe, the deviation from straightness is excessive.

b) If both ends of the gauge, when used as described in a) above, are not in contact with the internal surface of the pipe at both ends, reverse the gauge so that edge Y, placed as in a) above, is adjacent to the internal surface of the pipe.

If the two studs in edge Y cannot be made to touch the surface of the pipe simultaneously, the deviation from straightness is excessive.

Appendix D Crushing strength test methods for pipes

D.1 Testing machine

D.1.1 A testing machine having a device that will apply the load at a uniform rate of about 30 kN/m per minute, or in increments of not more than 1.5 kN/m at the same rate, shall be used for the test.

D.1.2 Ensure that the testing machine is substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part and that, under the maximum load, the deflection of the pipe is uniform throughout its length. The bearings shall be as specified in **D.1.3** and be attached to the machine so as to receive and uniformly transmit the maximum loads required in the tests without lost motion, vibrations or sudden shock. The machine and bearings shall be designed to transmit the load in a vertical plane through the longitudinal centre lines of the bearings and pipe. Where the testing machine is so constructed that, instead of a single load, a number of equal individual loads, equally spaced, are applied along the bearer, ensure that the resultant of all such individual loads acts at the centre of the overall length of the pipe. The loaded length of the pipe used in this test may extend over the socket, at the discretion of the manufacturer.

D.1.3 The bearings shall consist of a lower member, being a rigid beam, on which two bearing strips are symmetrically disposed parallel to a vertical plane passing through the longitudinal axis of the pipe, and an upper member, also being a rigid beam, on which one bearing strip is centred and disposed so that it lies in the vertical plane passing through the longitudinal axis of the pipe.

It is permissible to interpose a timber packing strip between the beam and the rubber bearing strip as shown in Figure 9.

Where pipes have been marked for laying in a specified position, such pipes shall be placed in the testing machine with the lifting hole at the top and directly under the centre of the upper bearer.

NOTE The machine may apply the test load either upwards or downwards on the unit under test. For convenience, the description given here is for top loading.

D.2 Procedure

D.2.1 The pipe to be tested shall be supported in a horizontal position on two bearings parallel to its longitudinal axis. Apply the load to it along the length of the pipe through a third bearing on top of the pipe.

D.2.2 Use a low carbon steel plate to face the upper flange of the bottom beam. Ensure that the facing is straight and free of warping or twisting and is centrally and permanently located on the flange of the beam. The cross section of the facing shall be rectangular, 330 mm × 25 mm minimum, without a joint and with the addition of steel wedge strips attached to it as shown in Figure 9.

D.2.3 The bearing strips shall consist of rubber cut or formed from material having a hardness between 55 IRHD and 65 IRHD measured in accordance with BS 903-A26. The top bearing strip shall be of rectangular cross section having a width of 150 mm and a thickness of not less than 25 mm and not more than 40 mm. The two bottom bearing strips shall be of equal width and thickness: 150 mm wide and 25 mm thick.

Use the single top bearing strip with the 150 mm face in contact with the pipe.

NOTE 1 The strip may be positioned on the bearing by the use of wood or metal strips along its outside edges, provided the thickness of each positioning strip does not exceed one-half the thickness of the rubber bearing strip.

Lay the lower bearing strips on the 150 mm face.

NOTE 2 The strips may be positioned on the bearing with wood or metal strips between them and adjacent to their outside edges, provided the thickness of each positioning strip does not exceed one-half the thickness of the rubber bearing strips.

Ensure that the two strips are parallel and 25 mm apart for all nominal sizes of pipe.

NOTE 3 The rubber bearing strips may be attached to the facings or, in the case of the single upper strip, directly to the upper beam by adhesive, provided such method of attachment results in the strip(s) remaining firmly fixed in position when carrying the maximum load.

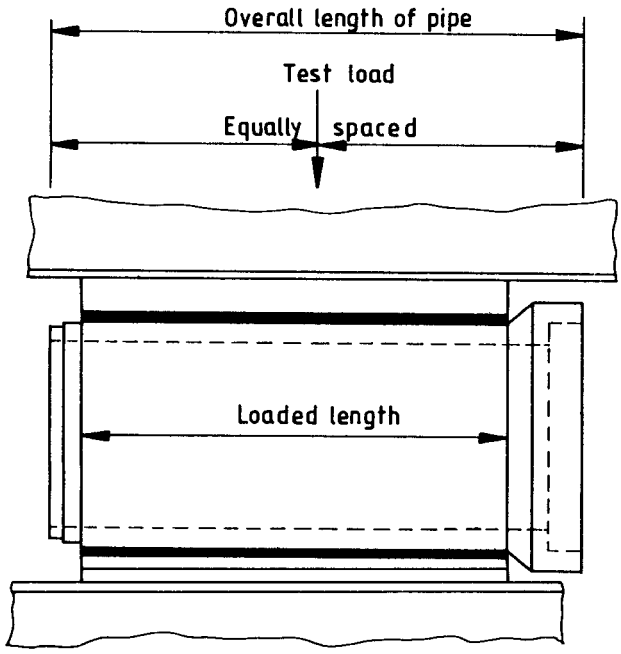
D.3 Loading

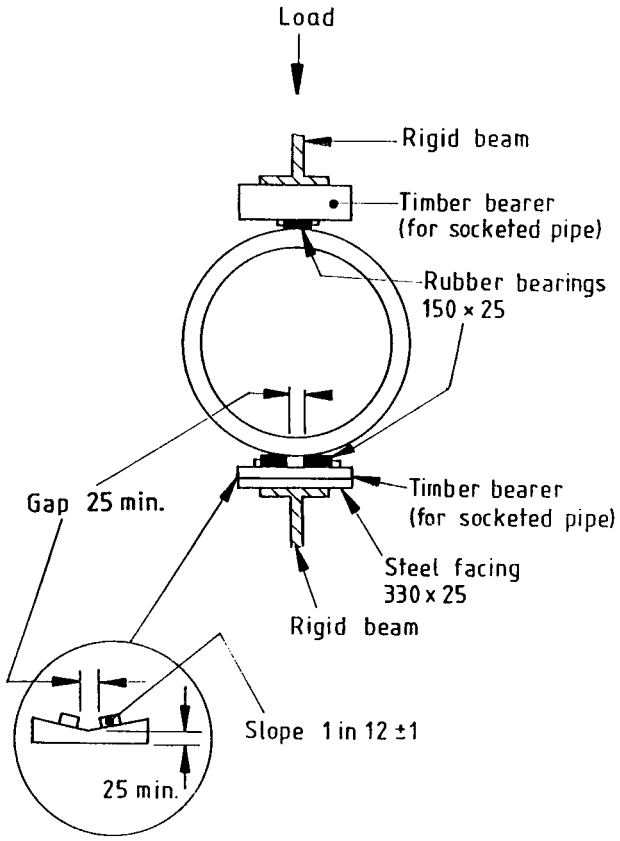
D.3.1 Apply the load to the top bearing at a point distant from the spigot end of the pipe equal to one-half of the overall length of the pipe including the socket, if any.

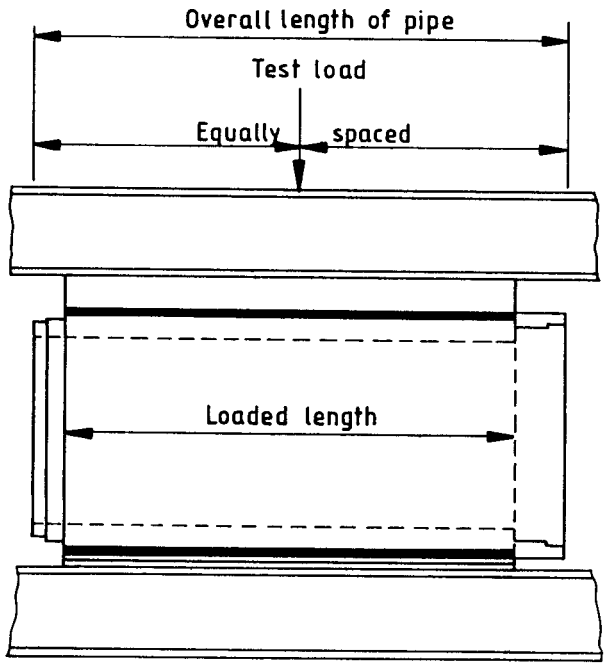
D.3.2 Apply the test load to the top bearing in such a way that the bearing is free to rotate in a vertical plane through the longitudinal centre lines of the top and bottom bearings.

D.3.3 Ensure that the loading of the pipe is a continuous operation, and that the pipe is not under load longer than is required to apply the load.

D.3.4 Inspect the pipe and measure any crack as described in **D.4**.

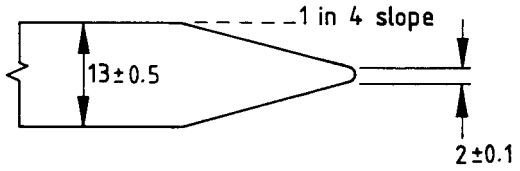






All dimensions are in millimetres.

Figure 9 — Testing arrangements for the crushing test



Thickness 0.25 ± 0.01
All dimensions are in millimetres.

Figure 10 — Dimensions of feeler gauge for inspecting cracks in reinforced units

D.4 Inspection of cracks (reinforced units)

Inspect any crack by means of a feeler gauge complying with the requirements of BS 957-2, with the dimensions as detailed in Figure 10.

Appendix E Method of test for water absorption

From each unit selected for test, take a specimen that is either approximately 100 mm square or a core approximately 75 mm in diameter and of the full thickness of the unit.

Alternatively, for monolithic bends and junctions cast as one piece, it is permissible to use as a specimen a concrete test cube compacted, cured and stored in the same way as the concrete in the unit.

Dry the specimen at a temperature of 100 ± 5 °C for not less than 72 h in a ventilated drying oven that complies with BS 2648. On removal from the oven, allow to cool to room temperature, weigh (M_1) and immediately submerge in potable water at a temperature of 20 ± 2 °C.

After 30 min, remove the specimen and immediately wipe with a dry towel for a total period of 30 s to remove surface water and reweigh (M_2).

After weighing, re-immerse the specimen in water for 23.5 h. Then remove, dry with a towel and weigh as before (M_3).

Calculate the 30 min and 24 hour percentage absorptions of dry mass from the formula:

$$\frac{\text{Wet mass } (M_2 \text{ or } M_3) - \text{dry mass } (M_1)}{\text{dry mass } (M_1)} \times 100\ \%$$

Appendix F Hydrostatic test method

F.1 Pipes

Apply the hydrostatic pressure to the whole pipe, including the portion of the socket or rebated joint that is subjected to pressure in the "as laid" condition.

Take care to remove all air from the pipe before the pressure is applied.

Apply internal hydrostatic pressure to the pipe at a rate not exceeding 0.07 N/mm^2 in 5 s.

After 1 min, reduce the pressure to just above atmospheric pressure and inspect the pipe for signs of leakage.

F.2 Bends and junctions

Carry out the test using expanding end stoppers or other suitable equipment.

Take care to remove all air from the unit before the pressure is applied.

Apply internal hydrostatic pressure at a rate not exceeding 0.035 N/mm^2 in 5 s.

After 1 min, reduce the pressure to just above atmospheric pressure and inspect the unit for signs of leakage.

Appendix G Bending moment resistance (BMR) test methods

NOTE The method described in **G.3** is suitable only when the mode of fracture is clearly "beam" failure. If there is doubt (e.g. if end crush occurs prior to the test load being achieved) the method described in **G.2** should be used.

G.1 General

G.1.1 *Testing machine.* The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The method of support and loading for the pipe shall be as described in either **G.2** or **G.3** and the load shall be applied to the pipe without vibration or sudden shock. The testing machine load shall be verified by the means detailed in BS 1610.

G.1.2 *Loading.* Apply the load at a uniform rate of between 6 kN/min and 9 kN/min or in increments of not more than 0.125 kN at the same rate.

G.2 Four-point loading test method

A whole pipe, or a part of a pipe with or without a socket, with an effective length greater than 1.25 m shall be used in the test.

Support the pipe in a horizontal position on two slings perpendicular to the axis of the pipe and symmetrical about the centre of its length. The two supporting slings shall be separated by a minimum support span of 0.9 m (see Figure 11). Apply the load to the pipe through two further slings, also perpendicular to the axis of the pipe. These loading slings shall be placed on top of the barrel, symmetrical about the centre of the gap between the support slings with a distance between centres fixed at 0.3 m.

Each sling shall be 0.15 m wide and shall be so designed that there is a contact angle of at least 120° around the pipe circumference. At no time during the test shall the pipe make contact with anything other than the four slings.

Calculate the BMR value as:

$$M = P_b \times \frac{a}{2}$$

where

M is the BMR (in kN m);

P_b is the total applied load (in kN);

a is the lever arm length = 0.5 (S – 0.3) (in m);

S is the support span (in m).

G.3 Three-point loading test method

A whole pipe, or a part of a pipe with or without a socket, and with effective length greater than a nominal length 1.25 m shall be used in the test.

Support the pipe to be tested on two wooden bearing blocks (as shown in Figure 12) placed in a horizontal position in the testing machine. The distance d between the centres of the bottom bearing blocks shall be 0.15 m less than the external length of the pipe barrel and they shall be placed symmetrically about the centre of its length (see Figure 13). Apply the load vertically to the top centre of the pipe barrel through a similar bearing block.

Bearing blocks shall each be approximately 1.5 × (DN) long, the pipe lying at right angles to the length and shall be lined with elastomeric material having hardness of 55 IRHD to 65 IRHD, of thickness 15 mm and width of 75 ± 5 mm. The two lower bearing blocks shall be of equal thickness.

Place the lower bearing blocks on a firm unyielding horizontal support and apply the load to the upper bearing block. (See Figure 13.)

Calculate the BMR value as:

$$M = P_b \times \frac{d}{4}$$

where:

M is the BMR (in kN·m);

P_b is the total applied load (in kN);

d is the distance between the centres of the bottom bearing strips (in m).

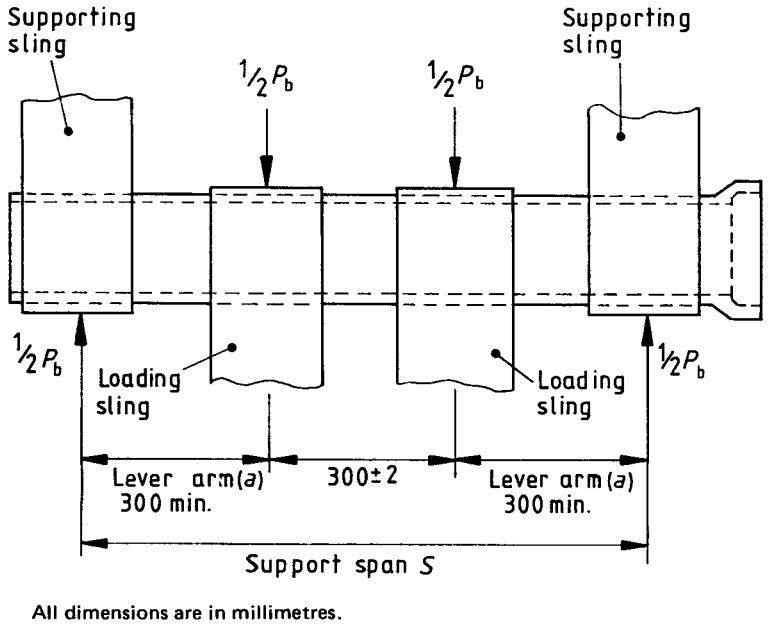


Figure 11 — Diagrammatic arrangement of the four-point loading test method

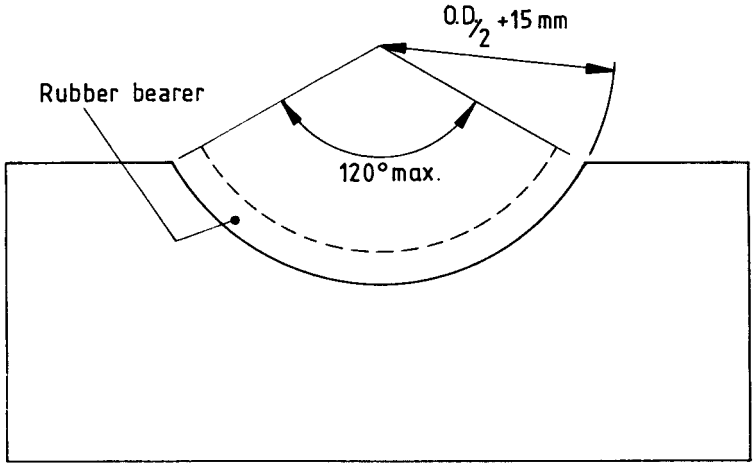


Figure 12 — Wooden bearing block for the three-point loading test method

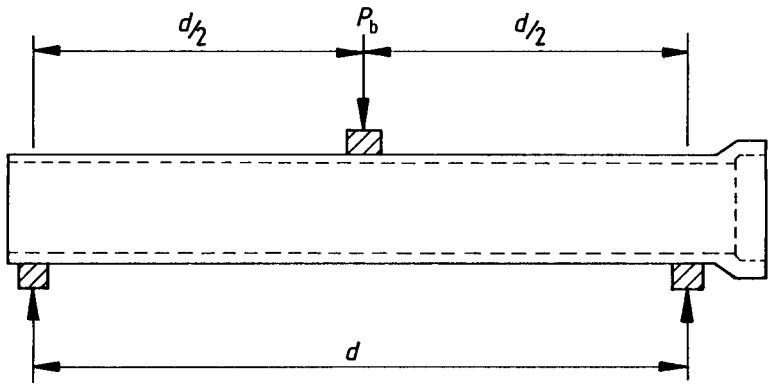


Figure 13 — Diagrammatic arrangement of the three-point loading test method

Appendix H Methods of testing pipe joints for angular deflection, straight draw and shear

NOTE The reduction in internal hydrostatic pressure and the increase in time of application for joints over DN 1800 in these tests is for safety reasons and to avoid excessive end thrusts.

H.1 Angular deflection

H.1.1 The test apparatus shall accommodate two complete pipes, or parts of pipes, flexibly jointed so as to allow movement in relation to each other up to the limits required by the test. The two complete pipes, or parts of pipes, shall be so jointed that the angular deflection is not less than that stated in **20.6.2** throughout the test.

H.1.2 Fill with water, taking care to remove all air from the pipes before the full pressure is applied.

Apply an internal hydrostatic pressure to the jointed pipes of 0.07 N/mm^2 for pipes up to and including DN 1800, or 0.035 N/mm^2 for pipes larger than DN 1800. Ensure that the rate of application is such that the maximum pressure is applied in not less than 5 s.

After 5 min for pipes up to and including DN 1800, or 10 min for pipes greater than DN 1800, reduce the pressure to just above atmospheric pressure and inspect the joint for signs of leakage.

H.2 Straight draw

H.2.1 The test apparatus shall be as described in **H.1.1** and shall be adjusted to maintain the amount of straight draw specified in **20.6.3** throughout the test.

H.2.2 Measure the joint gap between the pipes as laid before the test.

The two complete pipes, or part pipes, shall be axially aligned and jointed with a gap between the pipes equal to the as laid gap plus the minimum straight draw specified in **20.6.3**.

Test the pipes or part pipes as described in **H.1.2**.

H.3 Shear

H.3.1 Two pipes, or parts of pipes, shall be axially jointed with a gap between the pipes equal to the joint gap between the pipes as laid before the test, plus a nominal 10 mm on the centre line (see Figure 14). Their ends shall be restrained to prevent further longitudinal movement during the test.

The pipe having the socket of the joint being tested shall be supported on blocks at each end of its barrel and be restrained from movement. The second pipe shall have a minimum effective length of 1 200 mm (1 000 mm for DN 150) supported by a block at either its point of balance, or at least 600 mm from the joint being tested, whichever is the greater distance (see Figure 14). The length of the restraint or support, measured parallel to the pipe axis, shall be nominally 150 mm or 1/10 of the nominal size of the pipe, whichever is the greater.

H.3.2 When the joint has been assembled, fill with water, taking care to remove all air from the pipes.

Keep the temperature of the water within the range 5 °C to 24 °C.

Apply hydrostatic test pressure, as described in **H.1.2** and the appropriate test load specified in **20.6.4** as shown in Figure 14.

NOTE The test load may be applied upward or downward.

Maintain the test conditions for not less than 5 min.

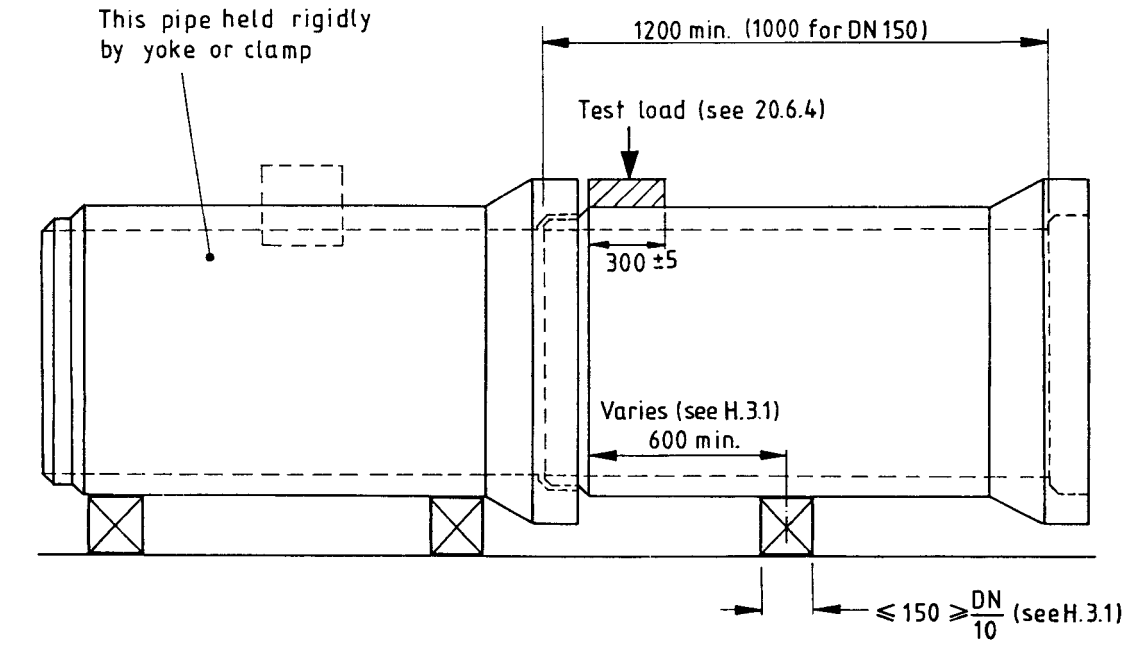
Reduce the pressure to just above atmospheric pressure and inspect the joint for signs of leakage.

H.4 Combined tests

H.4.1 The test apparatus shall be as described in **H.1.1**, and shall be adjusted to maintain the specified amounts of angular deflection and/or straight draw.

Where the combined test includes a shear test the pipe support apparatus shall also be as described in **H.3.1**.

H.4.2 First, carry out the test procedure as described in **H.1.2**. After the successful completion of the procedure, carry out the procedure described in **H.3.2**.



All dimensions are in millimetres.

Figure 14 — Loading arrangement for shear test on joints

Appendix J Methods of measuring depth of cover to reinforcement

Either make a channel at least 300 mm long and 25 mm wide to expose the reinforcement on all surfaces of the unit and measure the depth of cover or determine the depth of cover by taking cores or cut sections.

NOTE For checking units not forming part of the sample it is permissible to use an electromagnetic covermeter in accordance with BS 1881-204 and suitably calibrated for size of reinforcement and curved surfaces where appropriate.

Appendix K Facilities for purchasers

The purchaser or his representative, by arrangement with the manufacturer, should at all reasonable times have free access to the places where the units are manufactured and tested, for the purpose of examining quality control procedures and records and of witnessing the testing and marking of units.

Representative samples of the aggregates should be supplied to the purchaser on request.

When required by the purchaser, evidence of satisfactory performance of the concrete manufactured with such aggregates should be made available at the time of placing the order.

Where the manufacturer is not covered by a scheme of third party certification, the purchaser should be permitted to select samples for test, using the appropriate inspection criteria specified in this Part of BS 5911.

NOTE The allocation of the cost of carrying out any additional tests over and above the tests specified in this Part of BS 5911 is generally agreed between the manufacturer and the purchaser prior to testing.

Appendix L Anchorage pull-out test

L.1 Testing machine

The testing machine shall be substantial and rigid throughout and designed so as to apply a load up to 2.5 times the weight of the pipe to each anchorage without vibration or sudden shock. The testing machine (see typical arrangement in Figure 15) shall be verified by the means detailed in BS 1610.

The test shall be carried out on the mature concrete pipe no more than 10 days after casting.

L.2 Loading

Apply the load at a uniform rate of between 150 kN/min and 250 kN/min or in increments of not more than 1.5 kN at the same rate, up to 2.5 times the weight of the pipe.

NOTE The arrangement for loading should be such that the reactive support on the pipe for the testing machine is clear of the possible cone of failure around the anchorage point.

L.3 Reporting

Report whether or not the anchorage pulls out, and whether or not any visible damage has occurred to the concrete or anchorage.

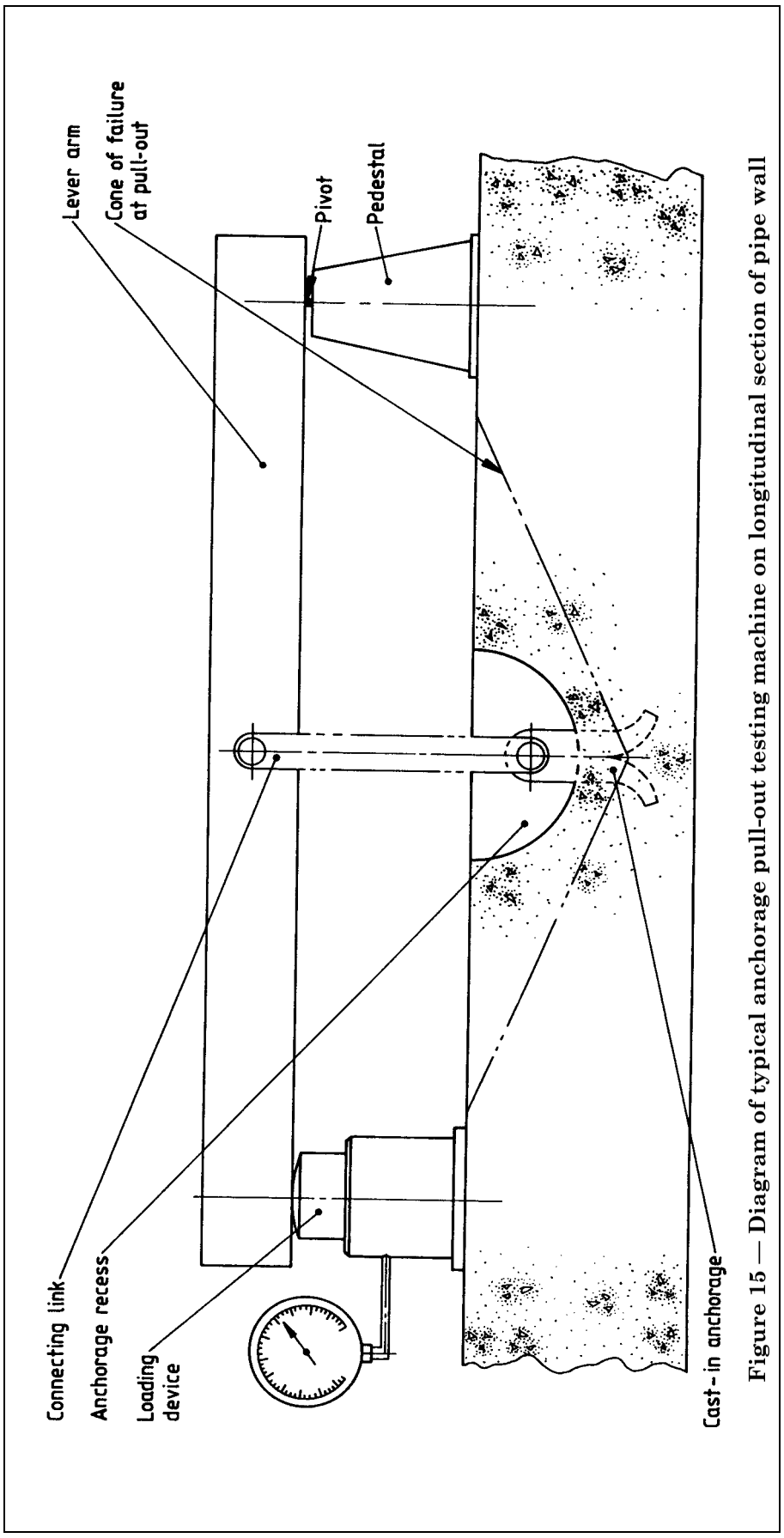


Figure 15 — Diagram of typical anchorage pull-out testing machine on longitudinal section of pipe wall

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Publications referred to

BS 12, *Specification for ordinary and rapid-hardening Portland cement.*

BS 65, *Specification for vitrified clay pipes, fittings and joints.*

BS 146, *Portland-blastfurnace cement.*

BS 146-2, *Metric units.*

BS 729, *Specification for hot dip galvanized coatings on iron and steel articles.*

BS 882, *Aggregates from natural sources for concrete.*

BS 903, *Methods of testing vulcanized rubber.*

BS 903-A26, *Determination of hardness.*

BS 957, *Specification for feeler gauges.*

BS 957-2, *Metric units.*

BS 970, *Specification for wrought steels for mechanical and allied engineering purposes.*

BS 970-1, *General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels.*

BS 1610, *Materials testing machines and force verification equipment.*

BS 1881, *Testing concrete.*

BS 1881-108, *Method for making test cubes from fresh concrete.*

BS 1881-111, *Method of normal curing of test specimens (20 °C method).*

BS 1881-116, *Method for determination of compressive strength of concrete cubes.*

BS 1881-120, *Method for determination of the compressive strength of concrete cores.*

BS 1881-204, *Recommendations on the use of electromagnetic covermeters.*

BS 2494, *Specification for elastomeric joint rings for pipework and pipelines.*

BS 2648, *Performance requirements for electrically-heated laboratory drying ovens.*

BS 3148, *Methods of test for water for making concrete (including notes on the suitability of the water).*

BS 3892, *Pulverized-fuel ash.*

BS 3892-1, *Specification for pulverized-fuel ash for use as a cementitious component in structural concrete.*

BS 4027, *Specification for sulphate-resisting Portland cement.*

BS 4360, *Specification for weldable structural steels.*

BS 4449, *Specification for carbon steel bars for the reinforcement of concrete.*

BS 4482, *Specification for cold reduced steel wire for the reinforcement of concrete.*

BS 4483, *Specification for steel fabric for the reinforcement of concrete.*

BS 5075, *Concrete admixtures.*

BS 5328, *Methods for specifying concrete, including ready-mixed concrete.*

BS 5911, *Precast concrete pipes, fittings and ancillary products.*

BS 5911-200, *Specification for unreinforced and reinforced manholes and soakaways of circular cross section Referred to in the foreword only*[5)].

BS 6000, *Guide to the use of BS 6001, sampling procedures and tables for inspection by attributes.*

BS 6001, *Sampling procedures for inspection by attributes.*

BS 6001-1, *Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

BS 6588, *Specification for Portland pulverized-fuel ash cement.*

BS 6699, *Specification for ground granulated blastfurnace slag for use with Portland cement.*

BS 8005, *Guide to sewerage.*

BS 8110, *Structural use of concrete.*

BS 8110-1, *Code of practice for design and construction.*

BS 8110-2, *Code of practice for special circumstances.*

BS 8301, *Code of practice for building drainage.*

[5)] Referred to in the foreword only.

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London
W4 4AL