DUS EAS 426-5

DRAFT UGANDA STANDARD

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Concrete pipes and ancillary concrete products — Part 5: Specification for ogee pipes and fittings (including perforated)

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National foreword

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Draft Uganda Standards adopted by the Technical Committee are widely circulated to stakeholders and the general public for comments. The committee reviews the comments before recommending the draft standards for approval and declaration as Uganda Standards by the National Standards Council.

This Draft Uganda Standard, DUS EAS 426-5: 2006, *Concrete pipes and ancillary concrete products — Part 5: Specification for ogee pipes and fittings (including perforated),* is identical with and has been reproduced from an East African Standard, EAS 426-5: 2006*, Concrete pipes and ancillary concrete products — Part 5: Specification for ogee pipes and fittings (including perforated),* and is being proposed for adoption as a Uganda Standard.

This standard was developed by the Building and civil engineering Standards Technical Committee (UNBS/TC 3).

Wherever the words, “East African Standard" appear, they should be replaced by "Uganda Standard."

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EAST AFRICAN STANDARD

Precast concrete pipes and ancillary concrete products — Part 5: Specification for ogee pipes and fittings (including perforated)

EAST AFRICAN COMMUNITY

First Edition 2006

Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to achieve this objective, the Partner States in the Community through their National Bureaux of Standards, have established an East African Standards Committee.

The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

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[Based on BS 5911-110:1992]

Introduction

This standard incorporates 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 ground or surface water at atmospheric pressure without suffering structural damage. Pipes to be installed in an environment aggressive to concrete should be the subject of special consideration, for example as regards depth of concrete cover to reinforcement.

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

Users of this standard are advised to consider the desirability of third party certification of product conformity with this standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality systems.

Precast concrete pipes and ancillary concrete products — Part 110: Specification for ogee pipes and fittings (including perforated)

Section 1: General

1 Scope

This Part of BS 5911 specifies requirements for precast concrete cylindrical units, perforated or unperforated, each with ogee or other rebated joints, either unreinforced or reinforced with steel cages or hoops. Perforated unreinforced pipes are also included.

The units specified are intended for drainage and for the construction of culverts, other than systems carrying foul water.

The specification covers constituent materials, dimensional requirements, performance requirements, appropriate test methods and inspection procedures.

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.

NOTE The titles of the publications referred to in this Part of BS 5911 are listed on page 26.

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
perforated pipe
an unreinforced concrete pipe with circular perforations

2.5
splayed end pipe
a pipe having one or both of its ends designed to be in a plane not at right angles to its longitudinal axis

2.6
rebated joint
a joint made within the wall thickness of a unit, including ogee joints

NOTE See Figure 1.

2.7
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

2.8
manufacturing diameter
a diameter of a unit that a manufacturer seeks to achieve

2.9
actual diameter
a diameter found by measurement

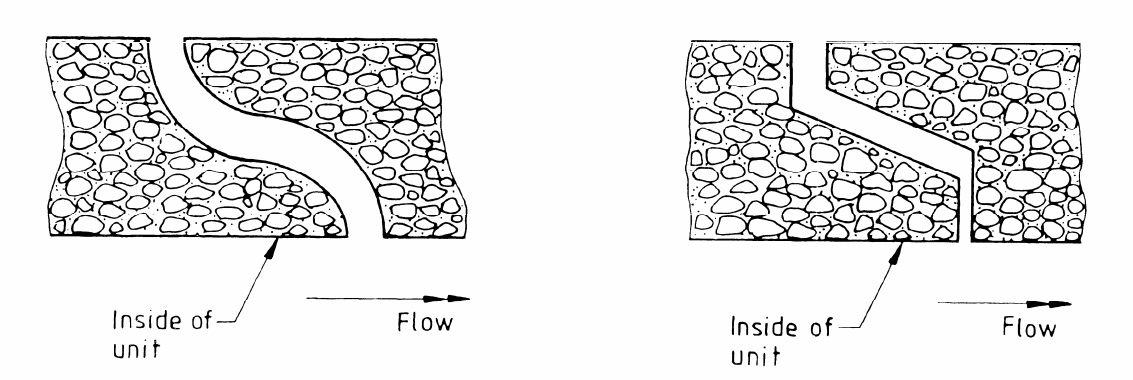


Figure 1 — Typical rebated joints

2.10
effective length
the length of a pipe measured as shown in Figure 2

2.11
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

2.12
batch
the number of units of a particular specification produced under uniform conditions during a givenproduction period by one particular process

2.13
reinforcement
steel, other than stainless steel, cast within a unit so as to reinforce the concrete, or to locate steel for that purpose

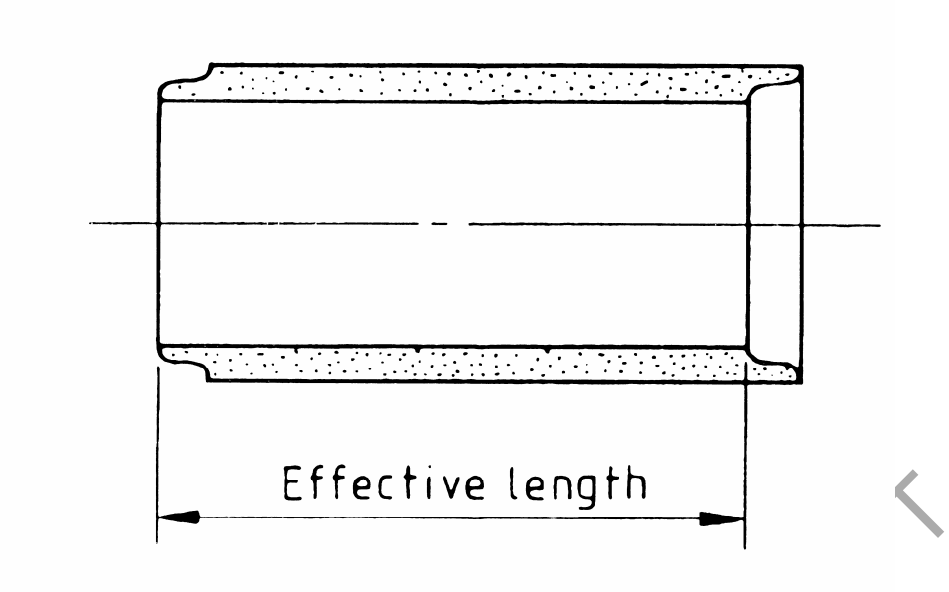


Figure 2 — Effective length of pipes

Section 2: Materials

3 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
Sulfate-resisting Portland	BS 4027
Portland pfa	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 sulfate, see note
ggbs	BS 6699	0 % to 65 %	70 % to 90 %
pfa	BS 3892-1	15 % to 35 %	25 % to 40 %

NOTE The minimum cement content and maximum water/cement ratio specified in **6.1** 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 itemb) will facilitate resistance to sulfate 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/m3. The advice of the pipe manufacturer should be sought where class 5 conditions exist.

4 Aggregates

4.1 General

Aggregates shall consist of materials complying with BS 882:1983 except that the manufacturer may modify the grading requirements of clause **5** of that standard (see clause **0** of BS 882:1983).

4.2 Testing

4.2.1 *Mechanical properties*

When tested in accordance with BS 812-111, BS 812-112 and BS 812-105.1 respectively 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.

4.2.2 Nominal maximum size

The nominal maximum size of aggregate shall not exceed the least of the following:

a) 20 mm;

b) the depth of concrete cover to reinforcement (see **7.2**);

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

5 Other concrete materials

5.1 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.

5.2 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-dosing and over-dosing.

6 Concrete mix, casting and finish

6.1 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 itemb) of clause **3**), the minimum cementitious content shall be increased from 360 kg/m^3 to 380 kg/m^3.

6.2 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

6.3 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.

6.4 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.

6.5 Surface finish

6.5.1 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.

6.5.2 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 **6.6.1**. The surface finish of units containing reinforcement shall be in accordance with **7.2**.

6.6 Making good

6.6.1 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 Association1). See also “The Repair of Concrete Structures” published by the Cement and Concrete Association2), which also deals with polymer latex mortars, and **6.10.5** of BS 8110-1:1985.

6.6.2 Blistering

Any blistering shall be made good using material complying with **6.6.1** d).

Flaking of the surface of a unit does not constitute blistering.

6.6.3 Joint surfaces

Before a unit is tested for compliance it is permissible:

a) subject to **6.4** to rework a joint profile for compliance with clause **15** by the application of material complying with **6.6.1** b) or c) to a depth not exceeding 5 mm whilst the concrete is still green, or material complying with **6.6.1** d), or by grinding off;

b) subject to **6.4** to make good using material complying with **6.6.1** b) or c) any spalling of the arrises of spigots or sockets that has occurred during de-moulding or handling.

6.6.4 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 **6.6.1** d) before the unit is assessed for compliance.

6.6.5 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 **6.5**.

7 Reinforcement

7.1 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

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. Longitudinal bars or wires or any other effective method shall be used to control spacing and shape and to ensure safe handling.

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

7.2 Protection for reinforcement

The concrete cover over all reinforcement 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.

There shall be no steel, other than stainless steel, within the concrete cover.

Reinforcement shall be free from mud, oil, paint, retarders, loose rust, loose mill 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.

Section 3: Dimensions and tolerances

8 Nominal size and effective length

8.1 Nominal size (DN)

The nominal sizes (see **2.7**) of units shall be either:

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

b) for perforated pipes, from DN 150 to DN 600, as given in Table 2.

8.2 Effective length of pipes

The effective length of pipes (see **2.10**) shall be in the range 0.45 m to 2.5 m inclusive.

Information shall be available on the effective lengths of pipes in a given nominal size named in an enquiry or order. (See Appendix A.)

9 Diameters

9.1 Internal manufacturing diameter and actual diameter

Information shall be made available at the enquiry stage, on the internal manufacturing diameters (see **2.8**) that can be supplied. (See Appendix A.) The internal manufacturing diameter shall not be outside the limits given in column 2 of Table 2.

The internal actual diameter (see **2.9**) shall not deviate from the manufacturing diameter by an amount greater than that given in column 3 of Table 2.

9.2 External manufacturing diameter

The external manufacturing diameter of the barrel of a unit (see **2.8**) shall be declared, if required. (See Appendix A.)

10 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.

11 Squareness of ends

Pipes other than splayed end pipes shall be capable of being aligned and jointed in all orientations with a minimum penetration of 50 % of the joint depth.

Table 2 — Nominal sizes and tolerances

1	2		3	4
Nominal size of units (see **8.1**)	**Limits of internal manufacturing diameter** (see clause **9**)		**Deviation of internal actual diameter from manufacturing diameter** (see clause **9**)	**Variation of wall thickness** (see clause **10**)
	Maximum diameter	**Maximum diameter**		
DN	**mm**	**mm**	**mm(±)**	**mm**
150	55	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

12 Deviation from straightness

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

13 Surface cracking

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

a) structural cracks that have developed in the tensile zone of reinforced concrete, within the limit specified in **19.4.2**, 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.

14 Perforations in pipes

Perforations shall have a total area of not less than 1 000 mm2 per metre length of pipe and shall be circular, with diameters not greater than 10 mm nor less than 3 mm.

NOTE Some spalling on the inner face can be tolerated around perforations.

15 Joints

The axial length of each joint of a unit shall be not less than 15 mm or (0.03DN + 7) mm, where DN is the nominal size of the unit, whichever is the greater. For example, for a section of DN 1 200, the axial length shall be not less than (0.03 × 1 200 + 7) mm = 43 mm. Other joint dimensions shall conform to the manufacturer's stated dimensions and tolerances.

NOTE For typical joints, see Figure 1.

16 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 materials specified in **6.6.1** d).

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

17 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.

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

Nominal size	Typical nominal angles	Minimum effective length
DN	degree	mm
150 to 225	45, 22.5, 11.25	300
300 to 600	45, 22.5, 11.25	450
675 and upwards	122.5, 11.25 1	500

NOTE 1 Bends may not necessarily have the same loadbearing 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.

Table 4 — Right-angled junctions

Nominal size		*A*	B
D	D_1		
See 8.1	To be the same size as *D* or any nominal size less than *D*	Not more than375 mm	See 8.2

Table 5 — Oblique-angled junctions

Nominal size		*B*
D	*D*	
See 8.1	To be the same size as *D* or any nominal size less than *D*	See 8.2

The 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.

When built up, the branch shall be secured with adhesive material (see **6.6.1**). Where cement/sand mortar is used it shall comply with **6.6.1** 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, this 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.

Junctions shall be marked as specified in clause **23** and sampled and tested in accordance with the appropriate requirements given in Table 6.

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 Junctions may not necessarily have the same loadbearing capacity as the pipes with which they are to be laid.

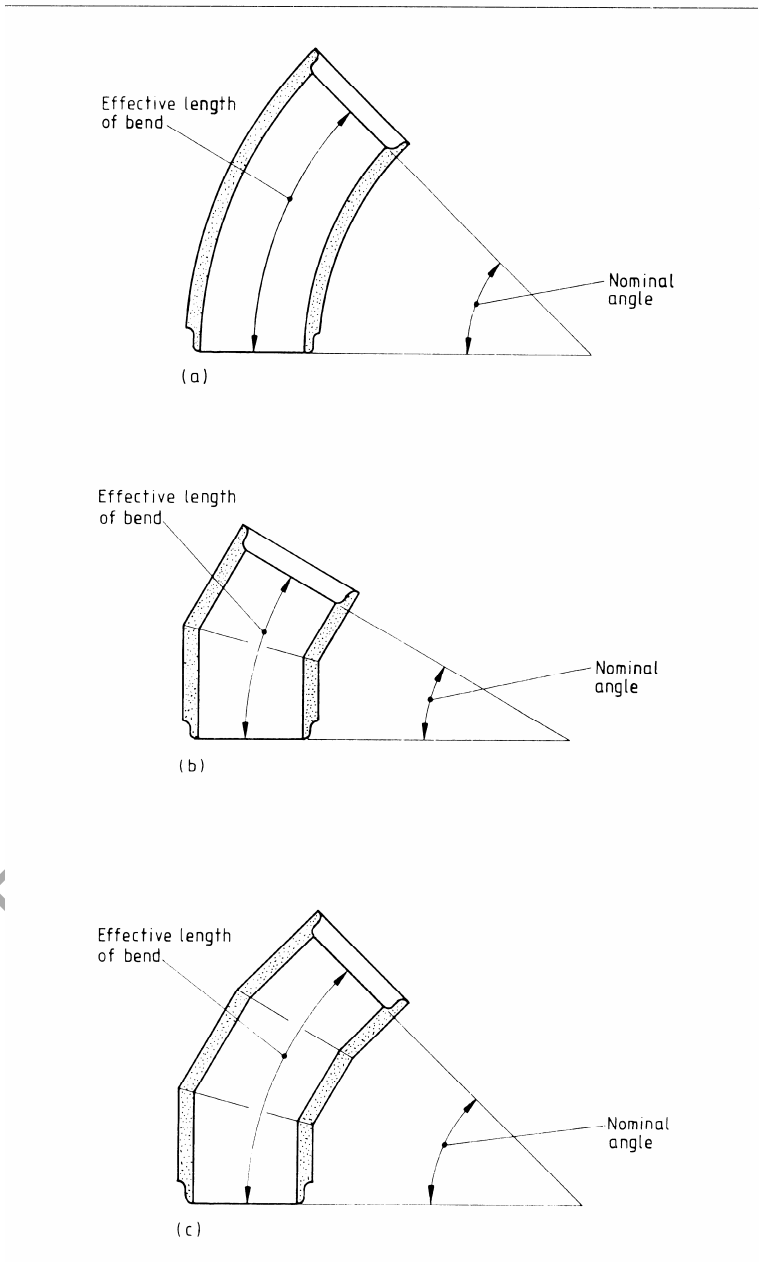


Figure 3 — Effective lengths of typical bends

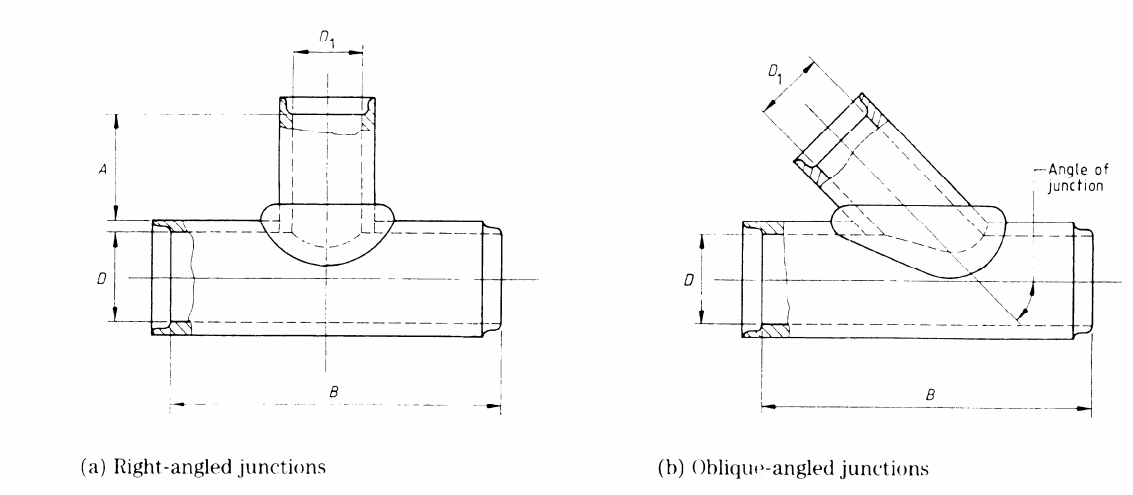


Figure 4 — Typical junctions

Table 6 — Summary of test requirements and inspection procedures

Unit	Nominal size and category	Test	Compliance requirements given in clause	Test method given in	Required as, type test (see	Required as routine test	Inspection procedures given in clause
Pipe	All	Surface evenness	6.5.1	Appendix B	—	—	See note 1
	All	Surface voids	6.5.2	Appendix B	—	—	See note 1
	All	Straightness	12	Appendix C	—	—	See note 1
	All	Water absorption	19.2	Appendix D	√	√	21.3
	All reinforced	Hydrostatic	19.3	Appendix E	√	√	21.1
	All reinforced	Works proof load	**19.4.2**	Appendix F	√	√	21.1
	All	Maximum load	**19.4.3**	Appendix F	√	√	21.2
	All ≤ DN 300	BMR	19.5	Appendix G	√	√	21.4
	All reinforced	Cover to reinforcement	**7.2,19.6**	Appendix H	√	√	21.2
Bend (cast in one piece)	All	Surface voids	6.5.2	Appendix B	—	—	See note 1
	All	Water absorption	19.2	Appendix D	√	√	22.3
	All reinforced DN 300	Hydrostatic	19.3	Appendix E	√	√	22.1
	All	Cube crushing	19.1	19.1	√	√	22.2
	All reinforced	Cover to reinforcement	**7.2, 19.6**	Appendix H	√	√	22.1
Bend (built up)	All reinforced ≤ DN 300	Hydrostatic(See note 2)	19.3	Appendix E	√	√	22.1
Junction (cast as one piece)	All	Surface voids	6.5.2	Appendix B	—	—	See note I
	All	Water absorption	22.3	Appendix D	√	√	22.3
	All reinforced ≤ DN 300	Hydrostatic	19.3	Appendix E	√	√	22.1
	All	Cube crushing	19.1	19.1	√	√	22.2
	All reinforced	Cover to reinforcement	**7.2, 19.6**	Appendix H	√	√	22.1
Junction (built up)	All reinforced ≤ DN 300 off ≥ DN 750	Hydrostatic (See note 2)	19.3	Appendix E	√	√	22.1

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 crushing strength test. See **21.1**.

Section 4: Tests

18 General

18.1 Routine and type testing

18.1.1 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 **21.1**.

18.1.2 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.

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

18.2 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 **19.3** and **19.4.2**.

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

Units cored and treated as specified in **19.2** or reinforced units that have passed the appropriate works proof load test and have not cracked under the load outside the limits specified in **19.4.2** shall be marked as specified in clause **23** and shall be taken to comply with this Part of BS 5911 in those respects.

19 Test requirements

19.1 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 and built-up bends and 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.

19.2 Water absorption test

Units, except fabricated bends and built-up junctions, built-up bends and junctions shall be sampled and tested in accordance with Appendix D.

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 **6.6.1** d).

19.3 Hydrostatic test for reinforced units only

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

The unit shall withstand an internal hydrostatic pressure of 0.14 N/mm2 (14 m head) if it is a pipe, or 0.07 N/mm2 (7 m head), if it is a bend or a junction, for a period of 1 min without cracking, leaking or showing other signs of distress. However, moisture appearing on the surface in the form of patches or beads adhering to the surface shall be permitted.

Prior to testing, the units shall not be treated with any coating or lining.

19.4 Crushing load tests for pipes

19.4.1 General

The maximum and works proof crushing test loads for pipes shall be:

a) those shown in Table 7; or

b) where stronger pipes are designed and manufactured, appropriate higher maximum loads with, in the case of reinforced concrete pipes, a works proof load equivalent to 80 % of the maximum load.

Table 7 — Crushing test loads for pipes

Nominal size of pipe	Class S		Class H	
	Works proof load (reinforced only)	Maximum load	Works proof load (reinforced only)	Maximum load
DN				
150	20	25	25	31
225	20	25	28	35
300	20	25	32	40
375	20	25	36	45
450	20	25	41	52
525	20	25	46	58
600	20	25	54	68
675	20	25	60	75
750	20	25	65	81
825	20	25	69	86
900	20	25	85	106
975	20	25	91	114
1050	20	25	96	120
1 125	20	25	106	133
1200	20	20	110	138

19.4.2 Works proof load test

When tested in accordance with Appendix F a reinforced pipe shall withstand for at least 1 min the appropriate works proof load specified in **19.4.1** for its size and class without developing a crack penetrable by a 0.25 mm feeler gauge described in **F.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 **7.2** 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.

19.4.3 Maximum load test

19.4.3.1 Unreinforced pipes

When tested in accordance with Appendix F an unreinforced pipe shall withstand, without showing signs of distress, the appropriate maximum test load specified in **19.4.1**.

19.4.3.2 Reinforced pipes

When tested in accordance with Appendix F, 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 **19.4.1**.

19.5 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 resistance appropriate to their size and class, as specified in Table 8, or, where stronger pipes are designed and manufactured [see **19.4.1** b)] an appropriate higher value.

NOTE See Appendix G.

Table 8 — Bending moment resistance (BMR)

Nominal size of pipe DN	Class S kN m	Class H kN m
150	3.4	4.5
225	8.1	11.2
300	15.9	24.2

19.6 Depth of cover to reinforcement

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

Units that have been successfully tested shall be made good with material complying with **6.6.1** d) before dispatch and shall be taken to comply with this Part of BS 5911 in that respect.

Section 5: Inspection procedures and marking

20 Type of inspection and batch size

20.1 Type of inspection

20.1.1 Normal inspection

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

20.1.2 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 **20.2**.

20.1.3 Reduced inspection

Reduced inspection shall be substituted for normal inspection only when permitted by the switching rules given in **20.2.4**.

20. Switching rules

20.2.1 General

Changes from one inspection type to another shall be in accordance with the following switching rules.

The rules given in **20.2.2**, **20.2.5** and **20.2.6** shall apply in all cases, whereas the rules given in **20.2.3** and **20.2.4** shall apply at the discretion of the manufacturer.

20.2.2 Normal to tightened inspection

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

20.2.3 Tightened to normal inspection

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

20.2.4 Normal to reduced inspection

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

a) the last 10 batches (see Table 9) 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 9. When double sampling is used, all samples inspected shall be included, i.e. not the first samples only.

Table 9 — Maximum number of individual defectives in last 10 batches permitted for switching reduced inspection (hydrostatic, works proof load (reinforced) and maximum load (unreinforced) 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 6001-1:1991 for a target acceptable quality level (AQL) of 6.5 %.	

20.2.4.2 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.

20.2.5 Reduced to normal inspection

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 10 or Table 11 as appropriate, 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.

20.2.6 Tightened inspection to stopping production

When using tightened inspection, stop production if it is not possible to switch to normal inspection (see **20.2.3**) after 10 consecutive batches.

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

20.3 Size of batch

When inspecting units, it is permissible to choose any size of batch (see **2.12**) provided that:

a) it is in accordance with **18.2**; and

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

Table 10 — Inspection plans for hydrostatic and works proof load crushing tests (reinforced pipes only)

1	2	3	4	5	6	7
Inspection type	Batch size	Sample size (See note 2)	**Accept**	Reject	Accept	Reject
			Number 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 see 20.3 b)
	281 to 500	13 (double)	1	4	4	5
	501 to 1200	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 see 20.3 b)
	281 to 500	13 (double)	0	3	3	4
	501 to 1200	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 see 20.3 b)
	281 to 500	5 (double)	0	4	1	5
	501 to 1200	8 (double)	0	4	3	6
NOTE 1 This table follows table's in BS 6001-1:1991 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.						

Table 11 — Inspection plans for maximum load crushing tests (unreinforced only)

1	2	3	4	5	6	7
Inspection type	Batch size	Sample size	Accept	Reject	Accept	Reject
			Number of failures			
Normal	2 to 50	2 (single)	0	1	-	-
	51 to 500	5 (double)	0	2	1	2
	501 to 3 200	8 (double)	0	3	3	4
	3 201 to 10 000	13 (double)	1	4	4	5
Tightened	2 to 50	3 (single)	0	1	-	-
	51 to 3 200	8 (double)	0	2	1	2
	3 201 to 10 000	13 (double)	0	3	3	4
Reduced	2 to 50	2 (single)	0	1	-	
	51 to 500	2 (double)	0	2	0	2
	501 to 3 200	3 (double)	0	3	0	4
	3 201 to 10 000	5 (double)	0	4	1	5

NOTE The above table is based on tables in BS 6001-1:1991 and is consistent with a target acceptable quality level (AQL) of 6.05 % at Special Inspection Level S3.

21 Inspection procedures for pipes

21.1 Inspection procedure for the hydrostatic or works proof load (reinforced) or maximum load (unreinforced) 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 crushing tests are being produced on a continuing basis.

NOTE The sampling plan in this clause follows BS 6001-1:1991, 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 produced as part of a regular pipe production process.

a) Determine the appropriate inspection type (see **20.1**).

b) Select the batch size (see **20.3**). 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 10 or Table 11 for the appropriate inspection type and size of batch.

d) Subject the sample to the hydrostatic test specified in **19.3** or the works proof load test (reinforced) specified in **19.4.2** or the maximum load test (unreinforced) specified in **19.4.3.1**.

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

   1) For batches of 25 or less (Table 10) or 50 or less (Table 11), i.e. single sampling, if the number of defectives is nil (see “Accept” number in column 4 of Table 10 or Table 11), accept

the batch. If the number of defectives is one or more (see “Reject” number in column 5 of Table 10 or Table 11), reject the batch.

2) For batches of 26 or more (Table 10) or 51 or more (Table 11), i.e. double sampling, if the number of defectives is equal to or less than the “Accept” number in column 4 of Table 10 or 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 10 or 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 **20.2.5** 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.

21.2 Inspection procedure for the maximum load crushing test and test for depth of cover to reinforcement (reinforced pipes only)

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 21.1, 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 19.4.3 and the depth of cover to reinforcement test specified in 19.6.

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 20.1.2).

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. Where a pipe fails the maximum load crushing test, the batch from which it was selected shall be rejected.

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.

21.3 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 pipe in 500 or two pipes per week, whichever is the greater, and take specimens as described in Appendix D. Use the same type of specimen for all tests on a given product.

b) Subject the specimens to the water absorption test specified in 19.2.

c) If the specimens pass the test, accept the pipes in the batch or batches from which they were taken. If any specimens 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 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 pipe 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.

21.4 Inspection procedure for bending moment resistance (BMR) test

21.4.1 Unreinforced pipes

In the size range up to and including DN 300 with effective length greater than 1.25 m from each batch of 30 selected for the maximum load test in accordance with 21.1, 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.

21.4.2 Reinforced pipes

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 21.2, select one pipe at random from the 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 Inspection procedures for bends and junctions

22.1 General

Unless otherwise specified in 22.2 to 22.3 inspection procedures for bends and junctions shall be the same as those for pipes in clause 21.

NOTE For guidance, see Table 6.

22.2 Inspection procedure for cube crushing test

When carrying out the cube crushing test specified in 19.1, 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 m3 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 19.1.

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

22.3 Inspection procedure for water absorption test

The inspection procedure shall be the same as that described in 21.3 except that, under 21.3 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 D.

23 Marking

23.1 Units of nominal size greater than DN 600

Each unit of nominal size greater than DN 600 shall be clearly marked with the following information:

a) the number of this British Standard, i.e. BS 5911-110;

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

c) an indication of the crushing test load(s), which shall consist of the letter "H" in accordance with Table 7 or, where other crushing test loads have been specified, the specific works proof and maximum crushing loads in kilonewtons per metre of effective length (see 2.10); if no indication of strength class is given it shall be taken as class "S".

d) a blue coloured mark where the unit is sulfate-resisting to class 3, or a yellow coloured mark where the unit is sulfate-resisting to class 4;

e) the day, month and year of manufacture;

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

g) where tests as described in 19.3 and 19.4 have been successfully carried out on the unit:

   1) the words "Hyd" or "Proof', as appropriate;

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

Bends shall additionally 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 unit.

23.2 Units of nominal size DN 600 or less

Each unit of nominal size DN 600 or less shall be clearly marked with the following information:

a) a blue coloured mark where the unit is sulfate-resisting to class 3, or a yellow coloured mark where the unit is sulfate-resisting to class 4;

b) where higher crushing test loads than those given for class S in Table 7 for a given nominal size of pipe have been specified, either the higher class strengths shown in Table 7 or the works proof and maximum crushing test loads in kilonewtons per metre of effective length.

NOTE Examples of marking.

1. BS 5911-110: with a blue mark

   1.12.92 "C" "X"

   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 5911-110; to be unreinforced, of class S and to be sulfate-resisting to class 3; and to have been made on 1 December 1992."

2. BS 5911-110 "R" 72/90

   12.1.93 "D" "Y" "Proof"'T"

   The above markings on a concrete pipe would signify: "Claimed by manufacturer "D" to have been made at his works "X" and to comply with BS 5911-110; to be reinforced and made to resist works proof and maximum crushing test loads of 72 kN and 90 kN per metre of effective length, respectively; to have been made on 12 January 1993 and to have been successfully subjected to the works proof load test, as specified in 19.3.2, with the results recorded in the manufacturer's quality control records "T"."

23.3 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.

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 8.1.)

b) If any restriction on effective length is to apply. (See 2.10.)

c) Crushing test loads of units, and whether units are required to be reinforced. (See 19.4.) 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 sulfate attack, if higher than class 2 (see clause 3).

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

f) If any restriction on admixtures is required. (See 5.2.)

g) If main reinforcement in a non-circular arrangement is acceptable. (See 7.1.)

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

i) If details of internal and external diameter are required. (See clause 9.)

j) Type of bend required. (See clause 16.)

k) Dimensions and materials of branch pipes for junctions. (See clause 17.)

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

m) If the products are to be covered by a third party certification scheme. (See Appendix J.) n) If units subject to the hydrostatic or works proof load crushing tests are not to be produced as part of a continuing series of batches, the specified inspection procedures (see 21.1).

Appendix B Method of assessing surface finish

B.1 Surface evenness

Place the gauge (see Figure 5) in the pipe so that its axis is parallel with the longitudinal axis of the pipe. Roll the gauge around the inside of the pipe, taking care to ensure that its axis remains parallel to the pipe 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 6) to the void and observe whether or not diametrically opposite points in the rim touch the surface of the unit simultaneously.

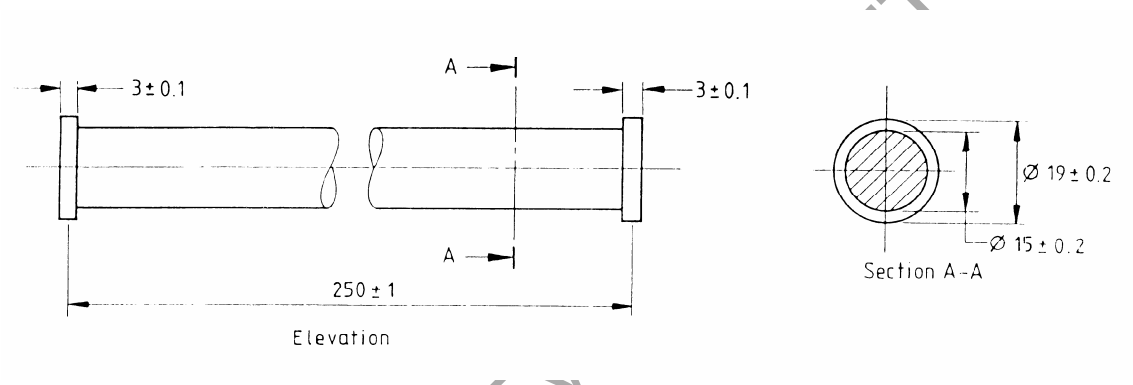


Figure 5 — Gauge for assessing surface evenness

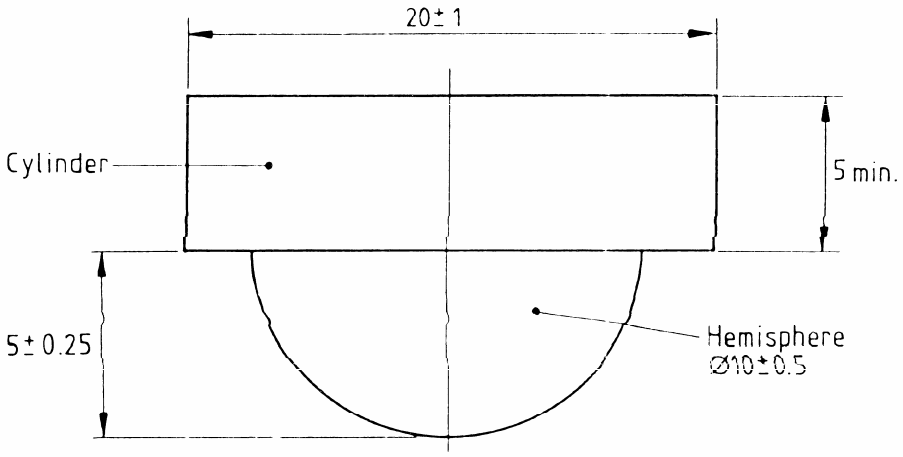


Figure 6 — Gauge for assessing surface voids

Appendix C Method of assessing the deviation from straightness

The deviation from straightness of pipes shall be assessed in the following manner.

a) Place a rigid straightedge, made into a gauge of the form and dimensions shown in Figure 7, 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.

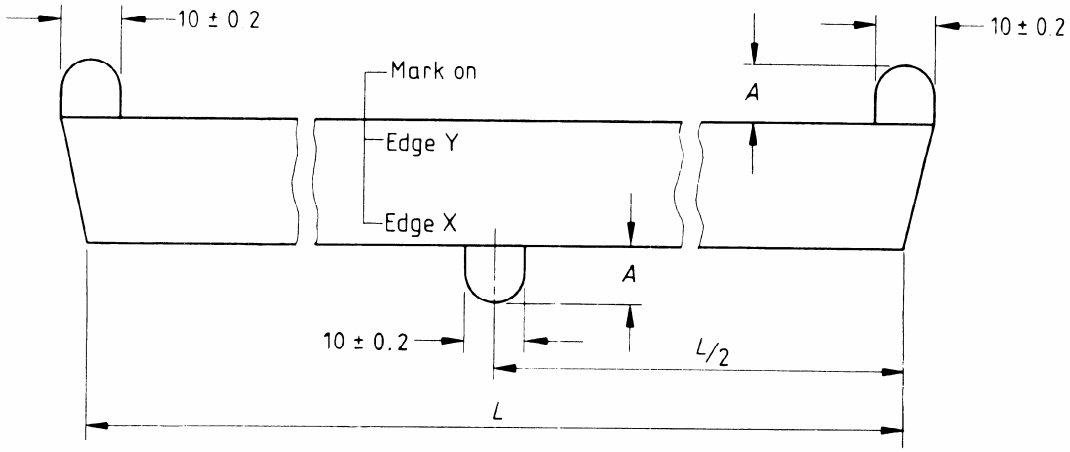
   If both ends of the gauge, when so placed, are in contact with the internal surface of the pipe, the deviation from straightness is excessive.

   If this condition occurs at any one of four or more different positions of the gauge, the pipe does not comply with this particular requirement.

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

   If this condition occurs at any one of four or more positions of the gauge approximately equally spaced around the pipe circumference, the pipe does not comply with this particular requirement.



All dimensions are in millimetres.

A = (3.5 x effective length of the pipe in m) 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.

Figure 7 — Gauge for assessing deviation from straightness

Appendix D 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 (Ml) 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 h percentage absorptions of dry mass from the formula:

$$\frac{wetmass(M_2 or M_3) - drymass(M1)}{drymass(M1)} \times 100\%$$

Appendix E Hydrostatic test method

E.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.

E.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/mm9 in 5 s.

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

Appendix F Crushing strength tests for pipes

F.1 Testing machine

F.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 making the test.

F.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 unit is uniform throughout its length.

The bearings shall be as specified in F.1.3 and shall be attached to the machine so as to receive and transmit uniformly 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 unit. 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 unit. The loaded length of the unit used in this test may extend over the joint, at the discretion of the manufacturer.

F.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 8.

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.

F.2 Procedure

F.2.1 The unit 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 unit through a third bearing on top of the unit.

In the case of perforated pipes, the centre line of the perforations shall be uppermost.

F.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 from 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 X 25 mm minimum, without a joint and with the addition of steel wedge strips attached to it as shown in Figure 8.

F.2.3 The bearing strips shall consist of rubber cut or formed from material having a hardness between 50 IRHD and 60 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 thickness: 150 mm wide and 25 mm thick.

Use the single top bearing strip with the 150 mm face in contact with the unit. It 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. They 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 unit.

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 if desired, provided such method of attachment results in the strip remaining firmly in position when carrying the maximum load.

F.3 Loading

F.3.1 Apply the load to the top bearing at a point distant from the male end of the unit equal to one-half of the overall length of the unit. 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.

F.3.2 Ensure that the loading of the unit is a continuous operation and that the unit is not under load longer than is required to apply the load. F.3.3 Inspect the unit and measure any cracks as described in F.4.

F.4 Inspection of cracks (reinforced units)

Inspect any crack by means of a feeler gauge complying with BS 957-2, with the dimensions as detailed in Figure 9.

All dimensions are in millimetres.

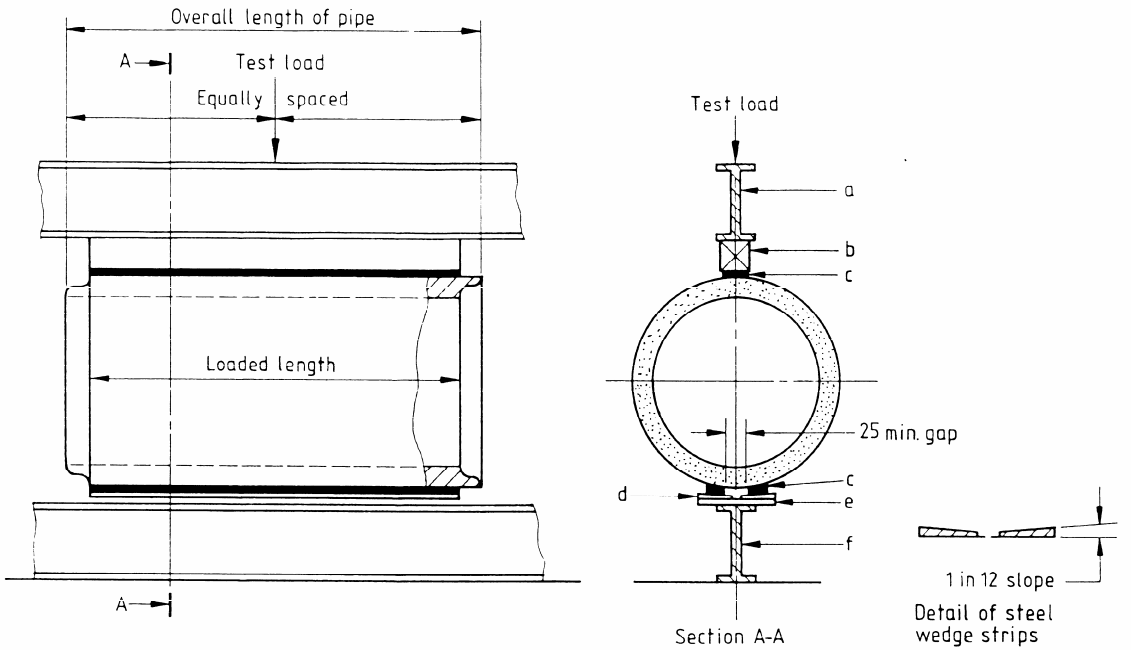


Figure 8 — Testing arrangement for the crushing test

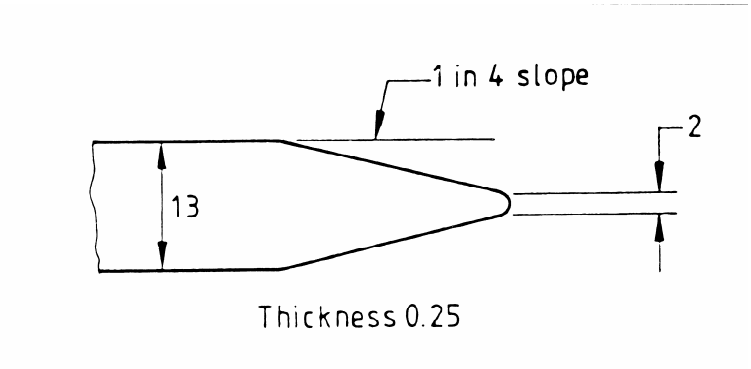


Figure 9 — Dimensions of feeler gauge for measuring crack widths

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 specified 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

A whole pipe, or a part of a pipe, 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. Each sling shall be 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 10). 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:

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

where

M is the BMR (in kN.m);

P_b is the total applied load (in kN);

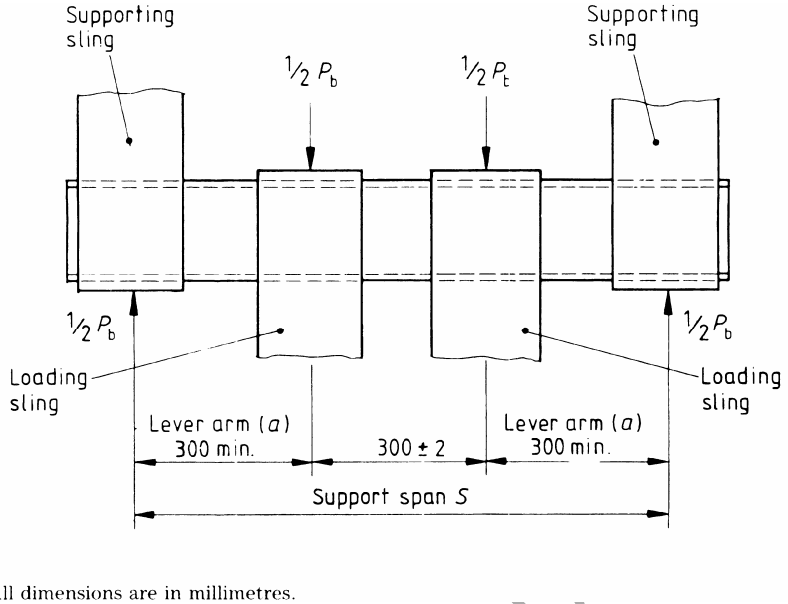
a is the lever arm length ='/2 (S - 0.3) (in m);

S is the support span (in m).

G.3 Three point loading test

A whole pipe, or a part of a pipe, 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 11) 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 12). Apply the load vertically to the top centre of the pipe barrel through a similar bearing block.



All dimensions are in millimetres.

Figure 10 — Testing arrangement for BMR test (four point loading)

Bearing blocks shall each be approximately 1.5 X (DN) long, the pipe lying at a 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 W horizontal support and apply the load to the upper O bearing block. (See Figure 12.)

Calculate the BMR as follows:

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

where

M is the BMR (in k·Nm);

P_b is the total applied load (in kN);

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

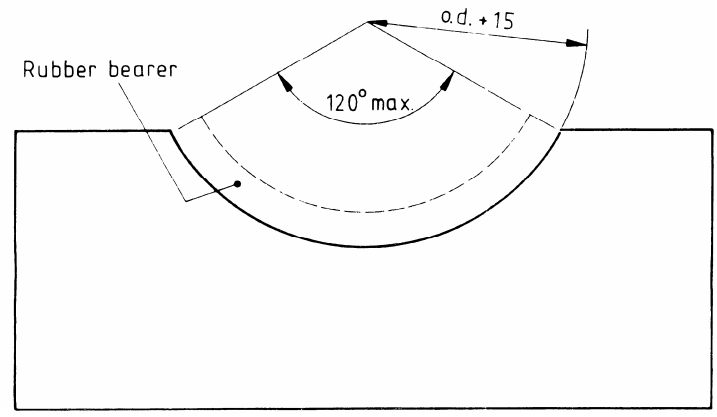


Figure 11 — Wooden bearing block for the three point loading test method

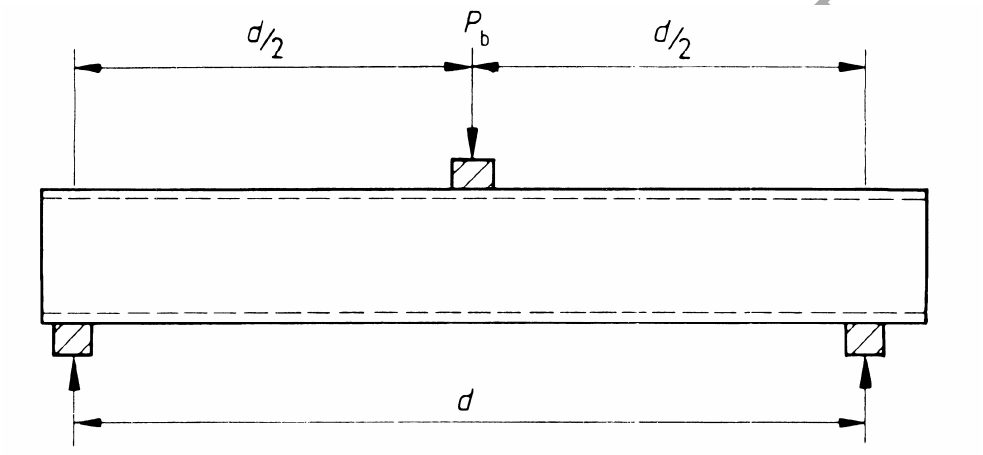


Figure 12 — Testing arrangement for BMR test (three point loading)

Appendix H 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 electronic cover-measuring device in accordance with BS 1881-204 and suitably calibrated for size of reinforcement and curved surfaces where appropriate.

Appendix J Facilities for purchasers

The purchaser or his representative, by arrangement with the manufacturer, should at all reasonable times have free access to the place where the units are manufactured and/or 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.

Publication(s) referred to

BS *12, Specification for Portland cement.*

BS 65, *Specification for vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely Q with surface water pipes and fittings.*

BS 146, *Specification for Portland-blastfurnace cement.*

BS 812, *Testing aggregates.*

BS 812-105, *Methods for determination of particle shape.*

BS 812-105.1, *Flakiness index.*

BS *812-111, Methods for determination of ten per cent fines value (TFV).*

BS 812-112, *Method for determination of aggregate impact value (AIV).*

BS 882, *Specification for aggregates from natural sources for concrete.*

BS 903, *Physical testing of 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 determinatiora of the* compressive *strength of concrete cores.*

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

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 sulfate-resisting Portland cement.*

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.* L

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

BS 5075, *Concrete admixtures.*

BS 5328, *Concrete.*

BS 5750, *Quality systems3~.*

BS 591 l, *Precast concrete pipes, fittings and ancillary products3~.*

BS 5911-100, *Specification for unreinforced and reinforced pipes and fittings with flexible joints.*

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 cements.*

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

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.*

A guide to design loadings for buried rigid pipes: HMSO:1983. U

Simplified tables of external loads ora buried pipelines: HMS0:1986.

Effective use of epoxy and polyester resins in civil engineering structures - CIRIA Report 69: Construction Industry Research and Information Association: 1978.

The repair of concrete structures: Cement and Concrete Association.

