

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.

AMD 6269
December 1989

Inside back cover

In the list of publications referred to delete the references to BS 4408 and BS 4461.

After the reference to BS 146 insert the following.

'BS 729 Specification for hot dip galvanized coatings on iron and steel articles'

After the reference to BS 1881 : Part 120 insert the following.

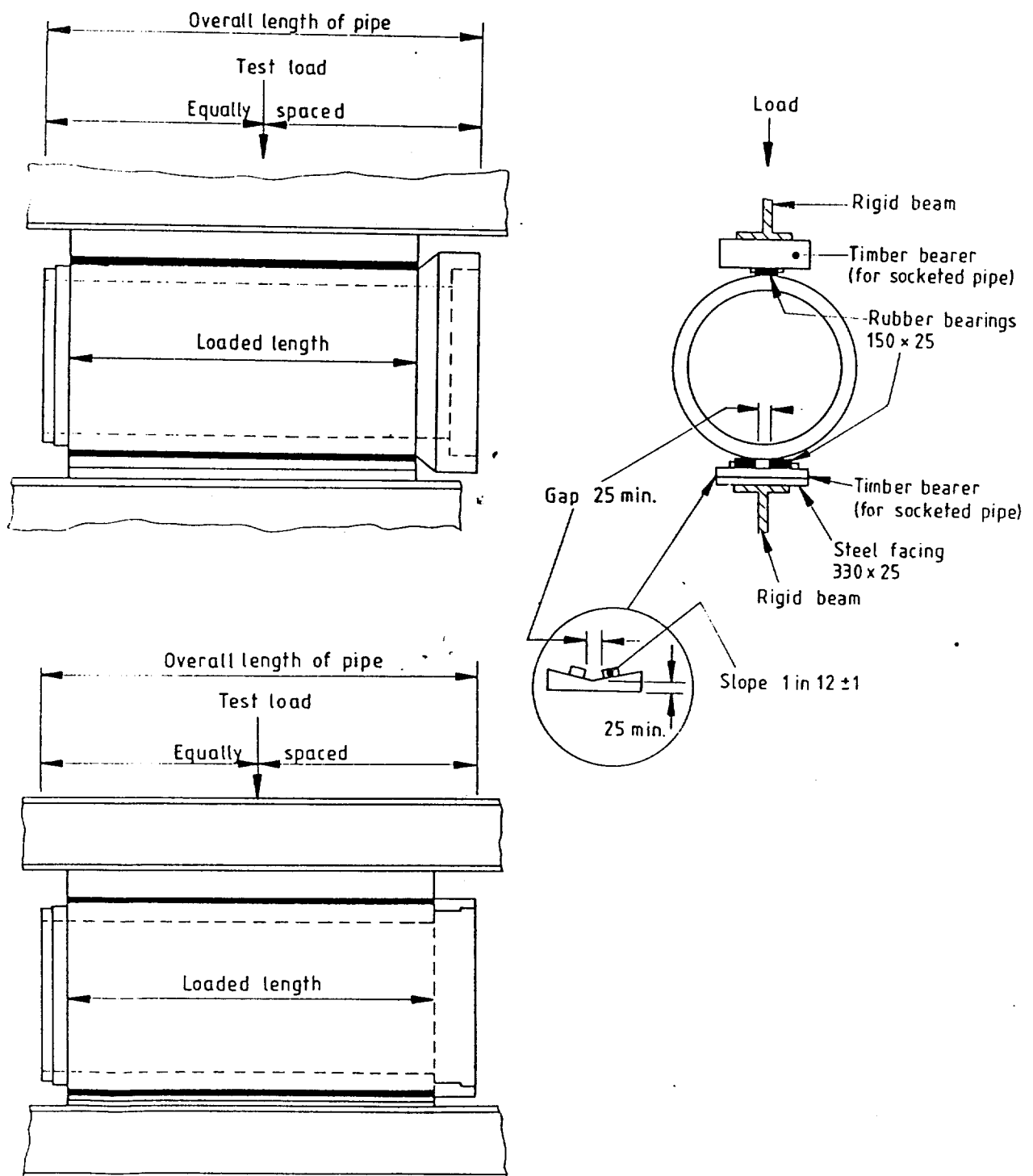
'Part 204 Recommendations on the use of electromagnetic covermeters'

After the reference to BS 4027 insert the following.

'BS 4360 Specification for weldable structural steels'

Delete the title of BS 4449 and substitute

'Specification for carbon steel bars for the reinforcement of concrete'.



All dimensions are in millimetres.

Figure 9. Testing arrangements for the crushing test

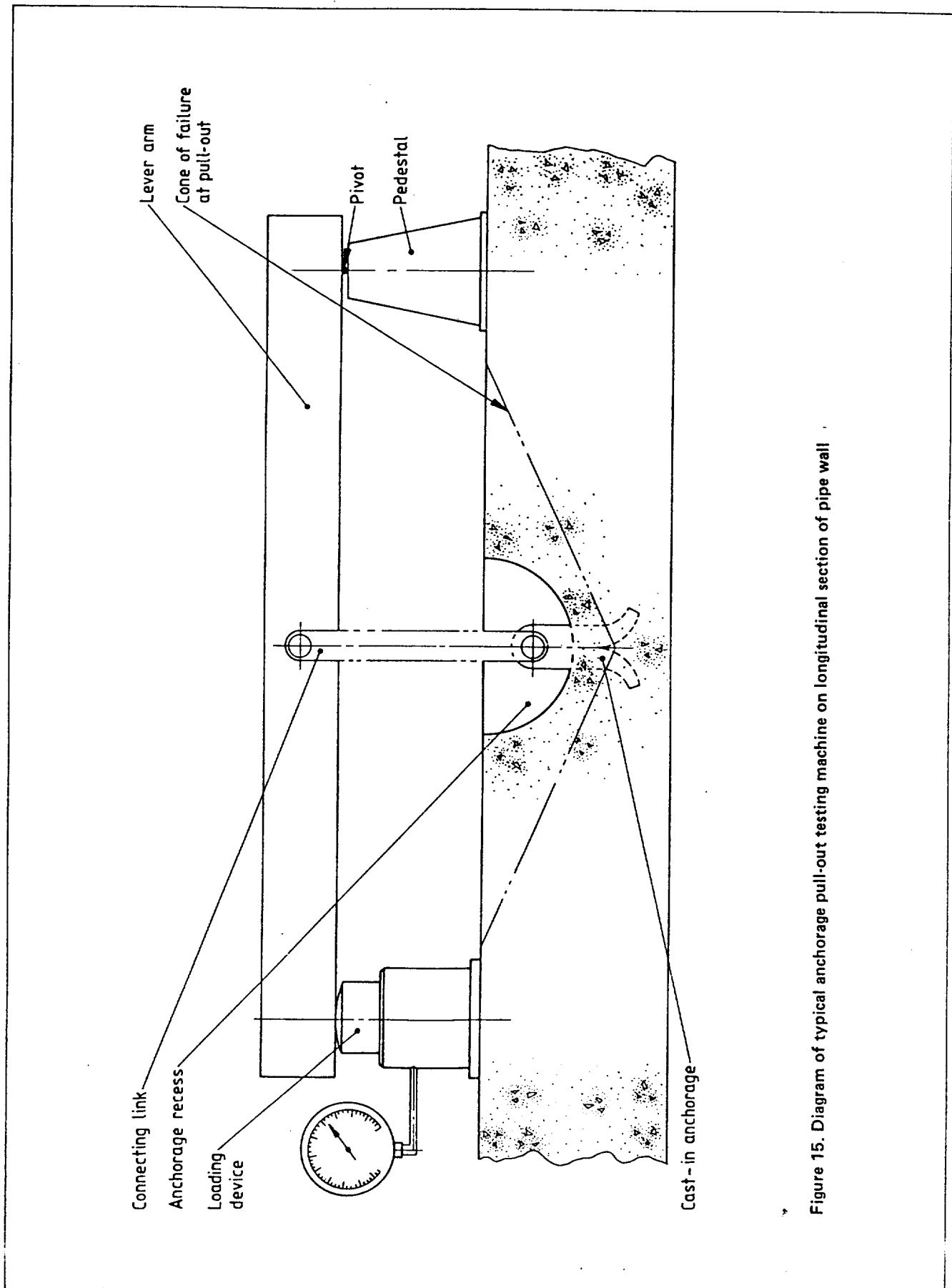


Figure 15. Diagram of typical anchorage pull-out testing machine on longitudinal section of pipe wall

Foreword

This revision of those clauses of BS 5911 : Part 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 form the subject of a new Part, Part 200*. When Part 200 is published, BS 5911 : Part 1 will be withdrawn.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.

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.

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

*In preparation.

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Section one. 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.

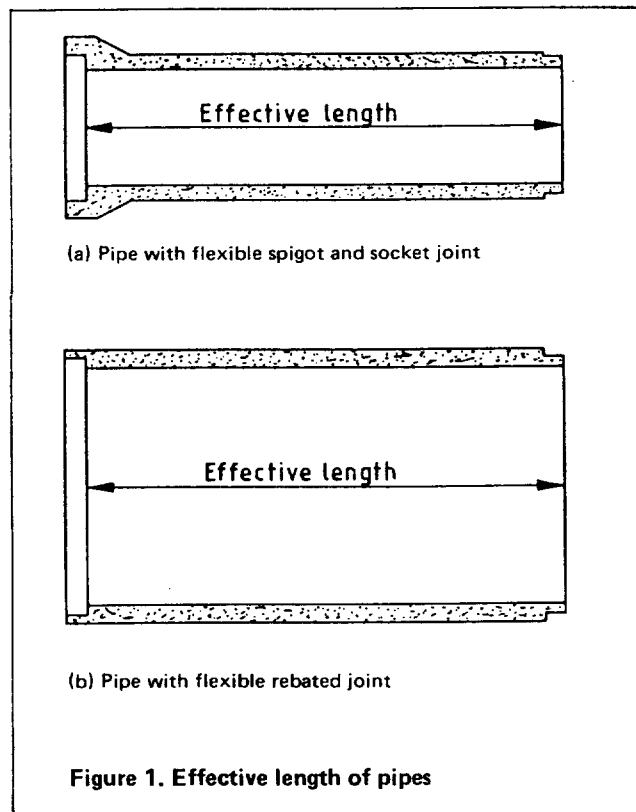


Figure 1. Effective length of pipes

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 : Part 100*;
- (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;

*Marking BS 5911 : Part 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.

- (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.

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 : Part 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 : Part 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.

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 $6 \times (DN) \text{ mm}^2$ with no individual area greater than $3 \times (DN) \text{ mm}^2$.

NOTE. For example, the total area for a DN 900 pipe is 5400 mm^2 with no individual area greater than 2700 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
Hot rolled steel bars for the reinforcement of concrete	BS 4449
Cold worked steel bars for the reinforcement of concrete	BS 4461
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. 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). 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 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 : Part 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 three. 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 pipes in the range DN 1200 to DN 3000, those halfway between the sizes in (a), i.e. at intervals of DN 75.

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.

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 (\pm)	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
1050	1070	1030	6	6
1125	1145	1105	6	6
1200	1220	1180	10	10
1350	1380	1330	10	10
1500	1530	1480	10	10
1650	1680	1630	10	10
1800	1830	1780	10	10
1950	1980	1925	16	16
2100	2135	2075	16	16
2250	2285	2225	16	16
2400	2435	2375	16	16
2550	2590	2525	16	16
2700	2740	2675	16	16
2850	2890	2825	16	16
3000	3040	2975	16	16

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;

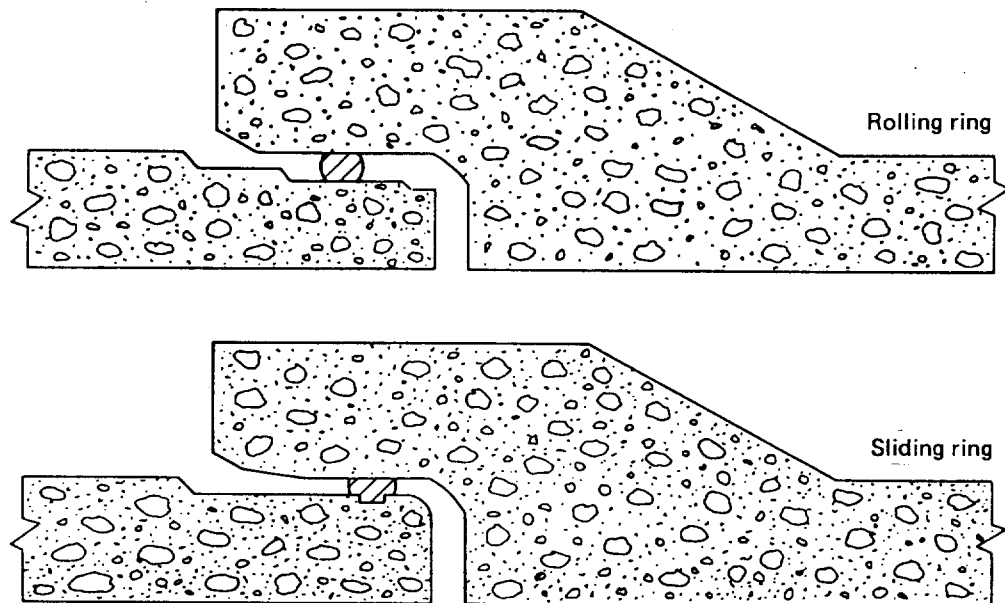
(b) crazing within any cement-rich surface layer.

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.

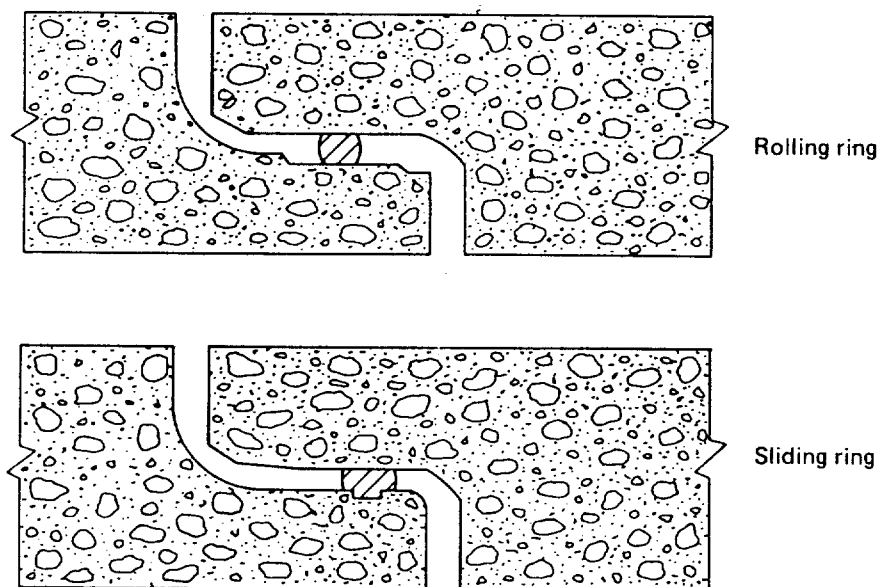
16 Joints

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.



(a) Socketed units



(b) Rebated units

Figure 2. Typical flexible joints

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 lengths, measured as shown in figure 3, shall be as given in table 3 for the appropriate nominal angles of bend.

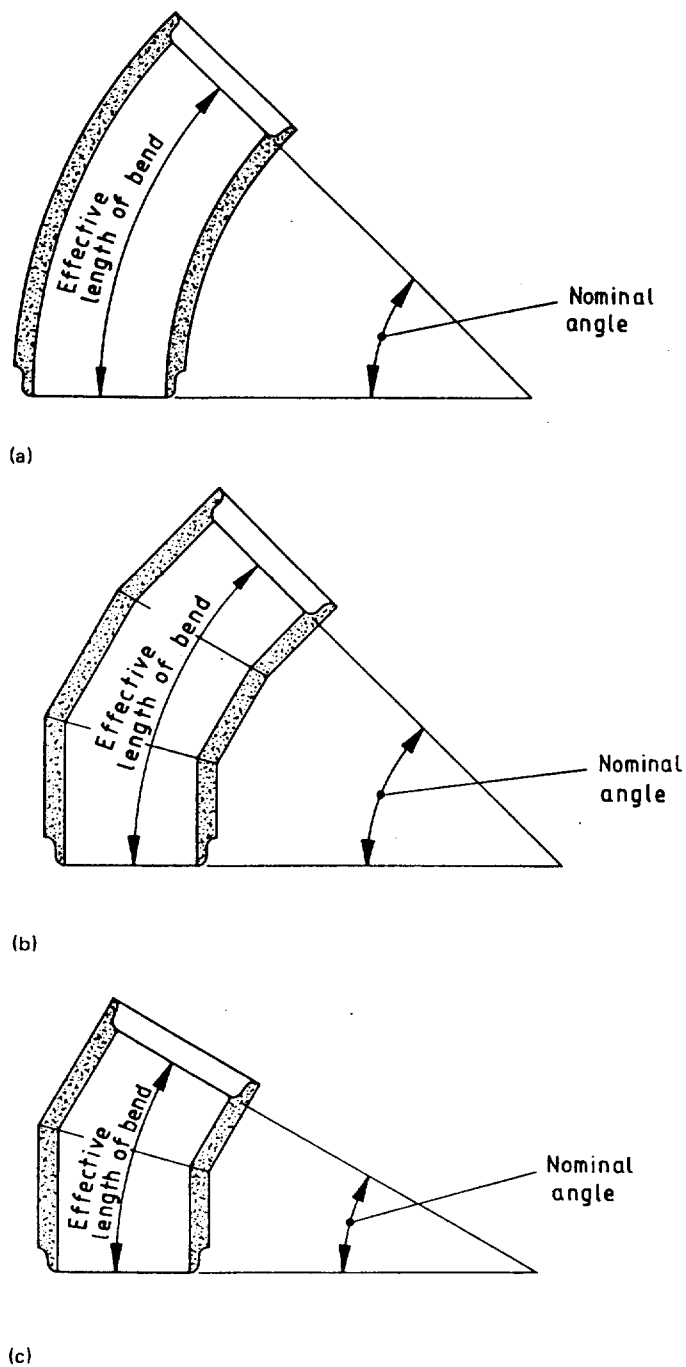


Figure 3. Typical bends

Table 3. Minimum effective lengths and nominal angles of bends		
Nominal size DN	Nominal angles	Minimum effective length
	degree	mm
150 to 225	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 tables 4 and 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.

Extreme Earthquake Forces (1+kv) (2)

Block No.	Level at Top of Blocks	Total Vertical Force	Total Horizontal Forces	Total Disturbing Moment	Total Restoring Moment	Factor of Safety		Resultant in middle third	Pressure at toe	Pressure at heel
						Sliding	Overturning			
1	4.00	153.27	-20.94	-9.98	490.47	7.32	49.12			
2	3.00	297.80	-48.08	-48.85	1063.64	6.19	21.77			
3	1.90	345.70	-60.54	-70.66	1240.86	5.71	17.56			
4	1.50	362.46	-64.60	-77.21	1299.53	5.61	16.83			
5	1.40	400.21	-82.08	-106.97	1431.78	2.44	13.38			
6	1.00	588.13	-126.63	-203.54	2391.39	4.64	11.75			
7	0.50	725.67	-197.14	-491.99	2413.98	1.84	4.91			
8	-0.70	993.00	-320.51	-1215.21	3087.39	1.55	2.54			
9	-2.40	1178.40	-518.02	-2734.89	4207.68	1.14	1.54			
10	-5.15	1363.81	-758.73	-5425.76	5825.29	0.90	1.07			
11	-7.90	1549.22	-1041.99	-9600.16	8149.48	0.74	0.85			
12	-10.65	1804.54	-1300.57	-13146.67	13281.93	1.39	1.01			
13	-12.30	1868.59	-1366.02	-14160.65	14075.16	1.09	0.99			
14	-12.80	2419.03	-1725.40	-20263.79	22708.45	1.12	1.12			
15	-14.90	3005.63	-2086.15	-27122.79	33409.34	1.15	1.23		683.59	-238.31
16	-16.75	0.00	0.00	0.00	0.00			n		

Restoring Forces

[illegible]

Restoring Forces

Block No.	Level at Top of Blocks	Friction on Virtual Back Active			Friction on Virtual Back Surcharge			Friction on Virtual Back Pos Earth		
		Force	Arm	Moment	Force	Arm	Moment	Force	Arm	Moment
1	4.00	0.92	6.40	5.90	2.70	6.40	17.26	1.26	6.40	8.05
2	3.00	4.53	7.00	31.69	7.02	7.00	49.14	6.53	7.00	45.73
3	1.90	6.16	7.00	43.10	8.10	7.00	56.69	8.95	7.00	62.62
4	1.50	6.59	7.00	46.13	8.37	7.00	58.58	9.59	7.00	67.10
5	1.40	8.43	7.00	58.99	9.45	7.00	66.13	12.30	7.00	86.12
6	1.00	14.49	8.50	123.20	13.51	8.50	114.81	23.99	8.50	203.88
7	0.50	21.61	7.60	164.23	16.74	7.60	127.25	34.51	7.60	262.29
8	-0.70	39.07	7.50	293.04	23.63	7.50	177.25	64.52	7.50	483.91
9	-2.40	65.78	7.50	493.34	31.05	7.50	232.87	104.03	7.50	780.25
10	-5.15	100.27	7.50	752.02	38.47	7.50	288.50	155.06	7.50	1162.97
11	-7.90	142.54	7.50	1069.09	45.88	7.50	344.12	217.61	7.50	1632.06
12	-10.65	230.01	9.50	2185.12	63.82	9.50	606.33	397.25	9.50	3773.87
13	-12.30	239.38	9.50	2274.15	65.17	9.50	619.14	411.12	9.50	3905.60
14	-12.80	300.90	11.50	3460.35	73.75	11.50	848.14	518.78	11.50	5965.92
15	-14.90	363.01	13.50	4900.70	81.59	13.50	1101.44	628.92	13.50	8490.47
16	-16.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Restoring Forces

Block No.	Level at Top of Blocks	Friction on Virtual Back Neg Earth			Friction on Virtual Back pos surcharge			Friction on Virtual Back neg surcharge		
		Force	Arm	Moment	Force	Arm	Moment	Force	Arm	Moment
1	4.00	1.19	6.40	7.60	3.68	6.40	23.57	3.48	6.40	22.24
2	3.00	6.17	7.00	43.17	10.61	7.00	74.30	10.02	7.00	70.16
3	1.90	8.46	7.00	59.20	12.21	7.00	85.47	11.54	7.00	80.76
4	1.50	9.06	7.00	63.45	12.61	7.00	88.26	11.92	7.00	83.41
5	1.40	11.64	7.00	81.50	14.21	7.00	99.44	13.43	7.00	94.01
6	1.00	22.74	8.50	193.27	22.22	8.50	188.90	21.04	8.50	178.86
7	0.50	32.73	7.60	248.73	27.01	7.60	205.29	25.59	7.60	194.45
8	-0.70	61.25	7.50	459.37	39.19	7.50	293.92	37.16	7.50	278.72
9	-2.40	98.75	7.50	740.62	50.16	7.50	376.22	47.58	7.50	356.83
10	-5.15	147.18	7.50	1103.85	61.14	7.50	458.51	57.99	7.50	434.93
11	-7.90	206.54	7.50	1549.05	72.11	7.50	540.81	68.40	7.50	513.03
12	-10.65	377.53	9.50	3586.53	110.26	9.50	1047.51	104.73	9.50	994.96
13	-12.30	390.69	9.50	3711.54	112.26	9.50	1066.46	106.63	9.50	1012.94
14	-12.80	493.03	11.50	5669.85	127.46	11.50	1465.79	121.08	11.50	1392.39
15	-14.90	597.75	13.50	8069.61	141.51	13.50	1910.32	134.43	13.50	1814.83
16	-16.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Restoring Forces

Block No.	Level at Top of Blocks	Crane Load			Bollard Horizontal			Bollard Vertical			
		Force	Arm	Moment	Load	Arm	Moment	Load	Arm	Moment	
1	4.00	457.14		5.50	2514.29		0.00		1.30	0.00	0.00
2	3.00	457.14		5.50	2514.29		0.00		2.40	0.00	0.00
3	1.90	457.14		5.50	2514.29		0.00		2.80	0.00	0.00
4	1.50	457.14		5.50	2514.29		0.00		2.90	0.00	0.00
5	1.40	457.14		5.50	2514.29		0.00		3.30	0.00	0.00
6	1.00	457.14		4.90	2240.00		0.00		3.80	0.00	0.00
7	0.50	457.14		4.00	1828.57		0.00		5.00	0.00	13.89
8	-0.70	457.14		3.00	1371.43		0.00		6.70	0.00	41.67
9	-2.40	457.14		3.00	1371.43		0.00		9.45	0.00	41.67
10	-5.15	457.14		3.00	1371.43		0.00		12.20	0.00	41.67
11	-7.90	457.14		3.00	1371.43		0.00		14.95	0.00	41.67
12	-10.65	457.14		4.50	2057.14		0.00		16.60	0.00	0.00
13	-12.30	457.14		4.50	2057.14		0.00		17.10	0.00	0.00
14	-12.80	457.14		5.50	2514.29		0.00		19.20	0.00	0.00
15	-14.90	457.14		6.50	2971.43		0.00		21.05	0.00	0.00
16	-16.75	0.00		0.00	0.00		0.00		0.00	0.00	0.00

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Restoring Forces

Block No.	Level at Top of Blocks	Static water on seaward side		
		Force	Arm	Moment
1	4.00	0.00	0.00	0.00
2	3.00	0.00	0.00	0.00
3	1.90	0.00	0.00	0.00
4	1.50	0.00	0.00	0.00
5	1.40	0.80	0.13	0.11
6	1.00	4.07	0.30	1.22
7	0.50	22.16	0.70	15.51
8	-0.70	72.56	1.27	91.91
9	-2.40	215.59	2.18	470.69
10	-5.15	434.61	3.10	1347.30
11	-7.90	729.64	4.02	2930.73
12	-10.65	943.14	4.57	4307.02
13	-12.30	1013.24	4.73	4796.01
14	-12.80	1335.09	5.43	7254.00
15	-14.90	1655.35	6.05	10014.86
16	-16.75	0.00	0.00	0.00

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Disturbing Forces

Block No.	Level at Top of Blocks	Concrete Blocks			Earthquake Concrete Blocks (1+kv)			Earthquake Concrete Blocks (1-kv)		
		Weight	Arm	Moment	Weight	Arm	Moment	Weight	Arm	Moment
1	4.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1.00	42.02	-0.30	-12.60	43.49	-0.30	-13.05	40.54	-0.30	-12.16
7	0.50	118.75	-0.72	-84.95	122.90	-0.72	-87.92	114.59	-0.72	-81.97
8	-0.70	208.67	-1.21	-252.88	215.97	-1.21	-261.73	201.37	-1.21	-244.03
9	-2.40	208.67	-1.21	-252.88	215.97	-1.21	-261.73	201.37	-1.21	-244.03
10	-5.15	208.67	-1.21	-252.88	215.97	-1.21	-261.73	201.37	-1.21	-244.03
11	-7.90	208.67	-1.21	-252.88	215.97	-1.21	-261.73	201.37	-1.21	-244.03
12	-10.65	76.12	-0.48	-36.23	78.78	-0.48	-37.50	73.45	-0.48	-34.96
13	-12.30	76.12	-0.48	-36.23	78.78	-0.48	-37.50	73.45	-0.48	-34.96
14	-12.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	-14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	-16.75	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00

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Summation of Forces

Static Forces (1)

Block No.	Level at Top of Blocks	Total Vertical Force	Total Horizontal Forces	Total Disturbing Moment	Total Restoring Moment	Factor of Safety		Resultant in middle third	Pressure at toe	Pressure at heel
						Sliding	Overturning			
1	4.00	145.18	-1.83	-0.61	467.52	79.13	764.44			
2	3.00	284.81	-7.91	-5.40	1032.76	36.02	191.27			
3	1.90	331.52	-11.96	-9.31	1210.97	27.73	130.10			
4	1.50	347.73	-13.27	-10.57	1269.22	26.20	120.10			
5	1.40	385.10	-18.94	-17.11	1406.56	10.17	82.22			
6	1.00	568.03	-25.07	-40.24	2373.99	22.66	58.99			
7	0.50	704.59	-45.27	-168.79	2437.12	7.78	14.44			
8	-0.70	973.66	-77.00	-513.01	3204.23	6.32	6.25			
9	-2.40	1174.87	-144.00	-1192.12	4481.20	4.08	3.76			
10	-5.15	1383.86	-226.49	-2574.59	6313.90	3.05	2.45			
11	-7.90	1600.63	-324.49	-4912.07	8911.58	2.47	1.81			
12	-10.65	1928.41	-367.48	-6523.91	14939.11	5.25	2.29			
13	-12.30	1998.06	-388.65	-7201.92	15803.48	4.11	2.19			
14	-12.80	2577.64	-475.47	-10513.24	25259.71	4.34	2.40			
15	-14.90	3191.84	-557.79	-14212.26	36933.89	4.58	2.60		197.69	275.17
16	-16.75	0.00	0.00	0.00	0.00			Y		

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Static Forces (2)

Block No.	Level at Top of Blocks	Total Vertical Force	Total Horizontal Forces	Total Disturbing Moment	Total Restoring Moment	Factor of Safety		Resultant in middle third	Pressure at toe	Pressure at heel
						Sliding	Overturning			
1	4.00	144.26	-1.83	-0.61	461.62	78.62	754.79			
2	3.00	280.28	-7.91	-5.40	1001.07	35.45	185.40			
3	1.90	325.36	-11.96	-9.31	1167.87	27.21	125.47			
4	1.50	341.14	-13.27	-10.57	1223.09	25.70	115.73			
5	1.40	376.67	-18.94	-17.11	1347.57	9.94	78.78			
6	1.00	553.53	-25.07	-40.24	2250.79	22.08	55.93			
7	0.50	682.98	-45.27	-168.79	2272.90	7.54	13.47			
8	-0.70	934.59	-77.00	-513.01	2911.19	6.07	5.67			
9	-2.40	1109.09	-144.00	-1192.12	3987.86	3.85	3.35			
10	-5.15	1283.59	-226.49	-2574.59	5561.88	2.83	2.16			
11	-7.90	1458.09	-324.49	-4912.07	7842.50	2.25	1.60			
12	-10.65	1698.39	-367.48	-6523.91	12754.00	4.62	1.95			
13	-12.30	1758.68	-388.65	-7201.92	13529.33	3.62	1.88			
14	-12.80	2276.74	-475.47	-10513.24	21799.36	3.83	2.07			
15	-14.90	2828.83	-557.79	-14212.26	32033.19	4.06	2.25		251.47	167.61
16	-16.75	0.00	0.00	0.00	0.00			y		

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Disturbing Forces

Block No.	Level at Top of Blocks	Active			Surcharge			Earthquake : Pos kv		
		Force	Arm	Moment	Force	Arm	Moment	Force	Arm	Moment
1	4.00	-1.83	0.33	-0.61	-5.37	0.50	-2.69	-2.51	0.33	-0.84
2	3.00	-7.91	0.68	-5.40	-10.74	1.02	-10.98	-11.22	0.68	-7.66
3	1.90	-11.15	0.82	-9.20	-12.89	1.22	-15.70	-16.02	0.82	-13.21
4	1.50	-12.02	0.86	-10.36	-13.42	1.27	-17.02	-17.30	0.86	-14.91
5	1.40	-15.67	1.01	-15.89	-15.57	1.47	-22.82	-22.70	1.01	-23.01
6	1.00	-19.29	1.19	-23.04	-17.18	1.73	-29.65	-31.57	1.19	-37.71
7	0.50	-33.46	1.63	-54.40	-23.62	2.29	-54.13	-52.53	1.63	-85.41
8	-0.70	-56.65	2.24	-126.96	-31.83	3.13	-99.70	-91.81	2.24	-205.76
9	-2.40	-109.83	3.21	-352.31	-46.60	4.45	-207.54	-170.49	3.21	-546.91
10	-5.15	-178.50	4.17	-745.21	-61.37	5.80	-355.98	-272.10	4.17	-1135.94
11	-7.90	-262.68	5.13	-1348.29	-76.13	7.16	-545.04	-396.64	5.13	-2035.86
12	-10.65	-297.38	5.69	-1691.68	-79.62	8.07	-642.38	-507.84	5.69	-2888.90
13	-12.30	-316.04	5.84	-1845.01	-82.31	8.30	-682.86	-535.45	5.84	-3125.89
14	-12.80	-392.31	6.55	-2571.00	-92.42	9.35	-863.85	-668.13	6.55	-4378.58
15	-14.90	-465.33	7.19	-3346.72	-101.22	10.28	-1040.73	-797.91	7.19	-5738.68
16	-16.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Disturbing Forces

Block No.	Level at Top of Blocks	Earthquake : Neg kv			Surcharge : Pos kv			Surcharge : Neg kv		
		Force	Arm	Moment	Force	Arm	Moment	Force	Arm	Moment
1	4.00	-2.36	0.33	-0.79	-7.33	0.50	-3.67	-6.92	0.50	-3.46
2	3.00	-10.59	0.68	-7.23	-15.89	1.02	-16.24	-15.00	1.02	-15.34
3	1.90	-15.14	0.82	-12.49	-19.07	1.22	-23.23	-18.02	1.22	-21.95
4	1.50	-16.36	0.86	-14.10	-19.86	1.27	-25.18	-18.77	1.27	-23.80
5	1.40	-21.49	1.01	-21.78	-23.04	1.47	-33.76	-21.79	1.47	-31.92
6	1.00	-29.93	1.19	-35.75	-28.08	1.73	-48.48	-26.59	1.73	-45.91
7	0.50	-49.82	1.63	-81.01	-37.61	2.29	-86.20	-35.64	2.29	-81.67
8	-0.70	-87.16	2.24	-195.32	-52.13	3.13	-163.27	-49.44	3.13	-154.84
9	-2.40	-161.82	3.21	-519.11	-73.98	4.45	-329.47	-70.17	4.45	-312.53
10	-5.15	-258.26	4.17	-1078.16	-95.82	5.80	-555.88	-90.91	5.80	-527.36
11	-7.90	-376.45	5.13	-1932.26	-117.67	7.16	-842.43	-111.64	7.16	-799.27
12	-10.65	-482.59	5.69	-2745.23	-136.67	8.07	-1102.66	-129.81	8.07	-1047.31
13	-12.30	-508.79	5.84	-2970.24	-140.64	8.30	-1166.87	-133.58	8.30	-1108.27
14	-12.80	-634.91	6.55	-4160.86	-158.60	9.35	-1482.42	-150.65	9.35	-1408.13
15	-14.90	-758.29	7.19	-5453.75	-174.54	10.28	-1794.58	-165.81	10.28	-1704.81
16	-16.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Disturbing Forces

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Disturbing Forces

Block No.	Level at Top of Blocks	Bollard Horizontal			Bollard Vertical			Earthquake Dead Load Horizontal		
		Load	Arm	Moment	Load	Arm	Moment	Load	Arm	Moment
1	4.00	-48.11	1.30	-62.54	-27.78	1.00	-27.78	-10.10	0.50	-5.05
2	3.00	-48.11	2.40	-115.47	-27.78	1.00	-27.78	-19.62	1.14	-22.37
3	1.90	-48.11	2.80	-134.71	-27.78	1.00	-27.78	-22.78	1.35	-30.75
4	1.50	-48.11	2.90	-139.52	-27.78	1.00	-27.78	-23.88	1.39	-33.19
5	1.40	-48.11	3.30	-158.77	-27.78	1.00	-27.78	-28.34	1.54	-43.64
6	1.00	-48.11	3.80	-182.82	-27.78	0.40	-11.11	-44.51	1.74	-77.45
7	0.50	-48.11	5.00	-240.56	-27.78	-0.50	0.00	-62.08	2.33	-144.64
8	-0.70	-48.11	6.70	-322.34	-27.78	-1.50	0.00	-89.85	3.22	-289.33
9	-2.40	-48.11	9.45	-454.65	-27.78	-1.50	0.00	-116.58	4.93	-574.73
10	-5.15	-48.11	12.20	-586.96	-27.78	-1.50	0.00	-143.30	6.73	-964.43
11	-7.90	-48.11	14.95	-719.26	-27.78	-1.50	0.00	-170.03	8.51	-1446.94
12	-10.65	-48.11	16.60	-798.64	-27.78	0.00	0.00	-202.12	9.38	-1895.84
13	-12.30	-48.11	17.10	-822.70	-27.78	0.00	0.00	-209.68	9.20	-1929.02
14	-12.80	-48.11	19.20	-923.73	-27.78	1.00	-27.78	-272.92	9.69	-2644.59
15	-14.90	-48.11	21.05	-1012.74	-27.78	2.00	-55.56	-340.48	10.22	-3479.67
16	-16.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Static Forces + Surcharge (1)

Block No.	Level at Top of Blocks	Total Vertical Force	Total Horizontal Forces	Total Disturbing Moment	Total Restoring Moment	Factor of Safety		Resultant in middle third	Pressure at toe	Pressure at heel
						Sliding	Overturning			
1	4.00	147.87	-7.20	-3.30	484.78	20.52	147.05			
2	3.00	291.83	-18.64	-16.38	1081.89	15.65	66.06			
3	1.90	339.62	-24.84	-25.01	1267.65	13.67	50.69			
4	1.50	356.10	-26.69	-27.58	1327.80	13.34	48.14			
5	1.40	394.55	-34.51	-39.92	1472.68	5.72	36.89			
6	1.00	581.54	-42.25	-69.89	2488.80	13.77	35.61			
7	0.50	721.33	-68.89	-222.91	2564.37	5.24	11.50			
8	-0.70	997.29	-108.83	-612.71	3381.48	4.58	5.52			
9	-2.40	1205.92	-190.59	-1399.65	4714.08	3.16	3.37			
10	-5.15	1422.32	-287.86	-2930.58	6602.40	2.47	2.25			
11	-7.90	1646.52	-400.62	-5457.11	9255.70	2.05	1.70			
12	-10.65	1992.23	-447.10	-7166.29	15545.44	4.46	2.17			
13	-12.30	2063.23	-470.96	-7884.78	16422.62	3.50	2.08			
14	-12.80	2651.39	-567.90	-11377.09	26107.85	3.74	2.29			
15	-14.90	3273.43	-659.01	-15252.99	38035.33	3.97	2.49		219.87	265.08
16	-16.75	0.00	0.00	0.00	0.00			y		

Static Forces + Surcharge (2)

Block No.	Level at Top of Blocks	Total Vertical Force	Total Horizontal Forces	Total Disturbing Moment	Total Restoring Moment	Factor of Safety		Resultant in middle third	Pressure at toe	Pressure at heel
						Sliding	Overturning			
1	4.00	144.26	-7.20	-3.30	461.62	20.02	140.03			
2	3.00	280.28	-18.64	-16.38	1001.07	15.03	61.13			
3	1.90	325.36	-24.84	-25.01	1167.87	13.10	46.70			
4	1.50	341.14	-26.69	-27.58	1223.09	12.78	44.34			
5	1.40	376.67	-34.51	-39.92	1347.57	5.46	33.76			
6	1.00	553.53	-42.25	-69.89	2250.79	13.10	32.20			
7	0.50	682.98	-68.89	-222.91	2272.90	4.96	10.20			
8	-0.70	934.59	-108.83	-612.71	2911.19	4.29	4.75			
9	-2.40	1109.09	-190.59	-1399.65	3987.86	2.91	2.85			
10	-5.15	1283.59	-287.86	-2930.58	5561.88	2.23	1.90			
11	-7.90	1458.09	-400.62	-5457.11	7842.50	1.82	1.44			
12	-10.65	1698.39	-447.10	-7166.29	12754.00	3.80	1.78			
13	-12.30	1758.68	-470.96	-7884.78	13529.33	2.99	1.72			
14	-12.80	2276.74	-567.90	-11377.09	21799.36	3.21	1.92			
15	-14.90	2828.83	-659.01	-15252.99	32033.19	3.43	2.10		285.74	133.35
16	-16.75	0.00	0.00	0.00	0.00			y		

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Section four. 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 five.

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.

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	App. B	—	—	See note 1
	All	Water absorption	20.2	App. E	✓	✓	22.3
	All	Hydrostatic	20.3	App. F	✓	✓	See note 3
	All	Works proof load	20.4.2	App. D	✓	✓	See note 3
	All	Maximum load	20.4.3	App. D	✓	✓	22.2
	All	Cover to reinforcement	8.2	App. J	✓	✓	22.2
	All	Straightness	14	App. C	—	—	See note 1
	All	Surface evenness	7.5.1	App. B	—	—	See note 1
	All	Joint deflection	20.6.2	App. H	✓	—	22.5
	All	Joint, straight draw	20.6.3	App. H	✓	—	22.5
	All	Joint, shear	20.6.4	App. H	✓	—	22.5
	≤ DN 300	BMR	20.5	App. G	✓	✓	22.4
Bend (monolithic)	All	Surface void	7.5.2	App. B	—	—	See note 1
	All	Water absorption	20.2	App. E	✓	✓	23.4
	All	Cover to reinforcement	8.2	App. J	✓	✓	22.2
	All	Cube crushing	20.1	20.1	✓	✓	23.2
	≤ DN 300	Hydrostatic	20.3	App. F	✓	✓	22.1 and 23.3
Bend (fabricated)	All	Surface void	7.5.2	App. B	—	—	See note 1
	All	Water absorption	—	—	✓	✓	See note 2
	≤ DN 300	Hydrostatic	20.3	App. F	✓	✓	22.1 and 23.3 See note 3
Junction (cast as one piece)	All	Surface void	7.5.2	App. B	—	—	See note 1
	All	Water absorption	20.2	App. E	✓	✓	23.4
	All	Cover to reinforcement	8.2	App. J	✓	✓	22.2
	All	Cube crushing	20.1	20.1	✓	✓	23.2
	DN 300 off DN 750	Hydrostatic	20.3	App. F	✓	✓	22.1 and 23.3 See note 3
Junction (built up)	All	Surface void	7.5.2	App. B	—	—	See note 1
	All	Water absorption	—	—	✓	✓	See note 2
	All	Cover to reinforcement	8.2	App. F	✓	✓	22.1 and 23.3
	DN 300 off DN 750 }	Hydrostatic	20.3	App. J	✓	✓	See note 3

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.

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.

If 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 : Parts 108, 111 and 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/mm². For other cements the strength shall be not less than 45 N/mm².

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 : Part 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/mm² (14 m head) and bends or junctions an internal hydrostatic pressure of 0.07 N/mm² (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.

NOTE 2. The use of a test pressure of 0.14 N/mm² 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 : Parts 1 and 2.

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
1050	51	64	76	95	96	120
1125	53	67	82	103	106	133
1200	58	72	87	109	110	138
1350	63	79	96	120	122	153
1500	69	87	104	130	132	165
1650	75	94	116	145	146	183
1800	82	103	124	155	158	198
1950	88	110	135	169	169	212
2100	96	120	146	183	184	230
2250	102	128	155	194	195	244
2400	108	135	165	207	210	263
2550	116	145	177	222	223	279
2700	124	155	186	233	235	294
2850	130	163	195	244	251	314
3000	135	169	207	259	260	326

NOTE 1. Works proof load for each size and class of pipe is 80 % of maximum load rounded off to the nearest kilonewton 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).

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. NOTE. See appendix A(c).

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

20.6 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 $0.025 \times (\text{DN})$ 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 $0.025 \times 1200 = 30$ kN.

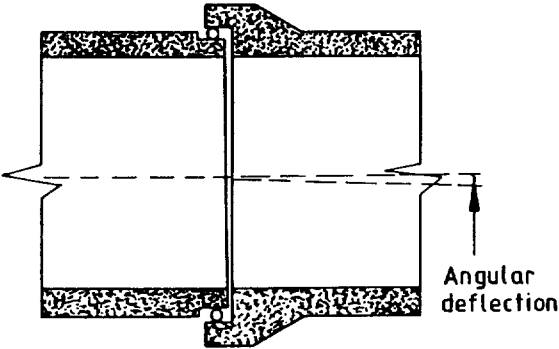
20.7 Test for depth of cover to reinforcement

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

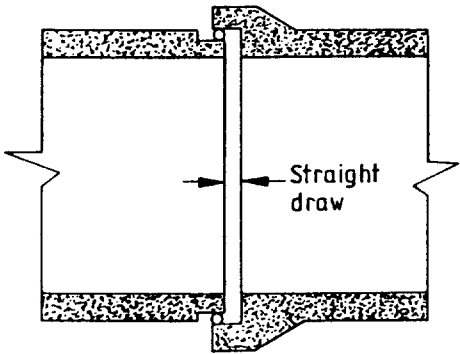
Units that have been successfully tested shall be made good with material complying with 7.6.1(d) before despatch and shall be taken to comply with this Part of BS 5911 in that respect.

Table 9. Minimum angular deflection and straight draw for joints

Nominal size of pipe DN	Minimum angular deflection	Minimum straight draw
150 to 600	degree 2	mm 20
675 to 1200	1	20
1350 to 1800	0.5	20
Above 1800	To be stated by the manufacturer	



(a) Angular deflection of joint



(b) Straight draw of joint

Figure 5. Joint test measurements

Section five. 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 1249	42

NOTE. The values in this table are consistent with those in table VIII of BS 6001 : Part 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) it is 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 : Part 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.

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
	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
	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
	281 to 500	5 (double)	0	4	1	5
	501 to 1200	8 (double)	0	4	3	6

NOTE 1. The above table follows tables in BS 6001 : Part 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).

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.

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.

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**, 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 **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/mm² at a rate of loading of 0.035 N/mm² 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.

Appendices

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.)

Appendix B. Methods of assessing surface finish

B.1 Surface evenness

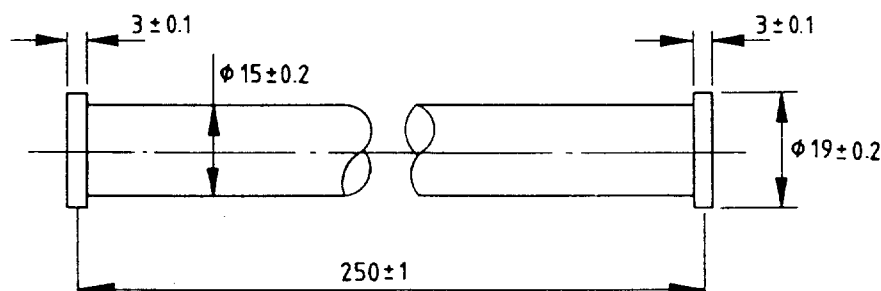
Place the gauge (see figure 6) in the pipe so that its axis is in the same plane as the longitudinal axis of the pipe.

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.

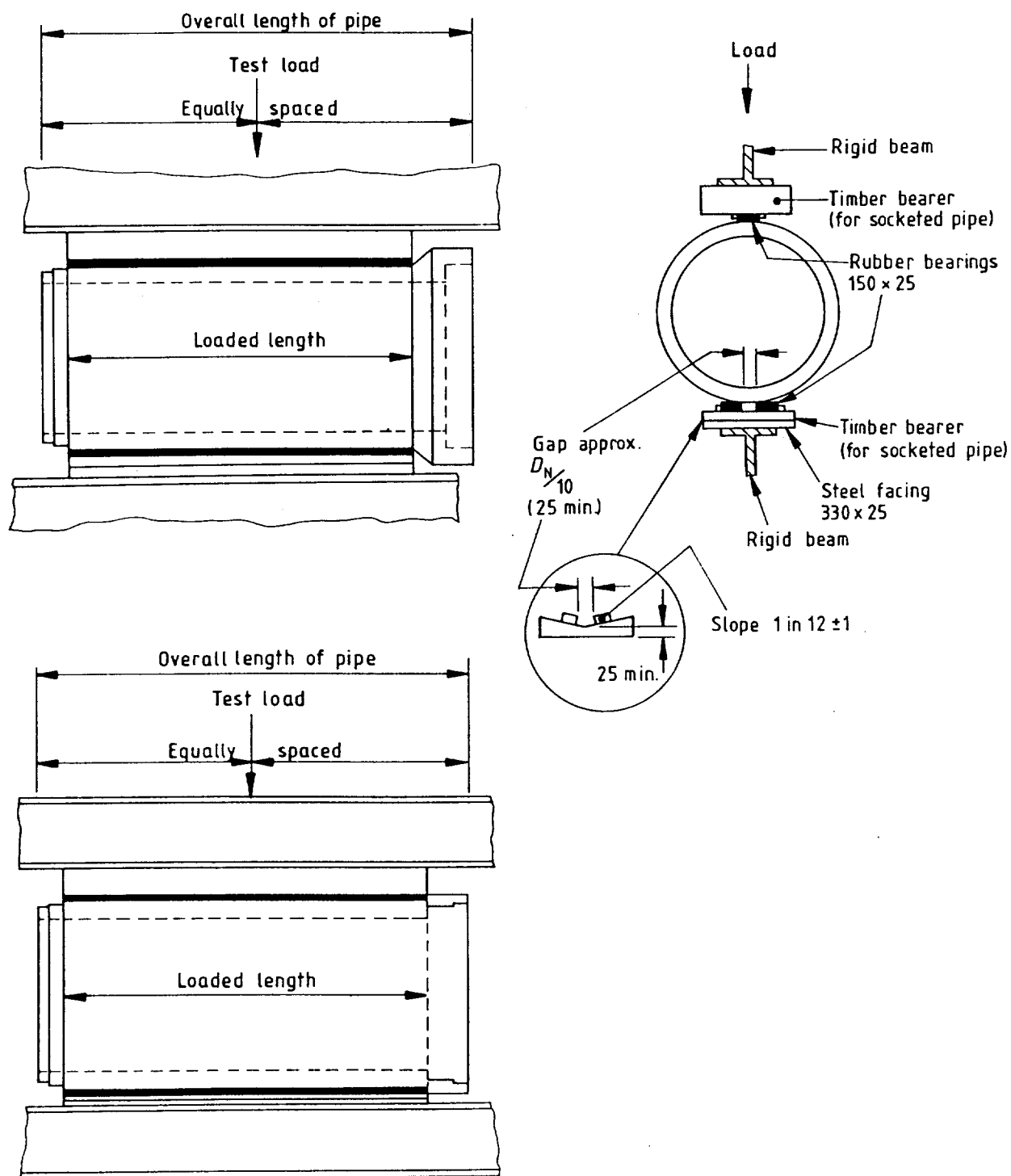
B.2 Surface voids

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

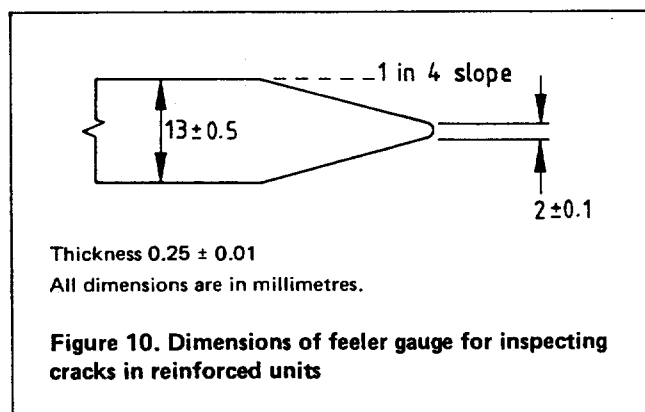


All dimensions are in millimetres.

Figure 9. Testing arrangements for the crushing test

D.4 Inspection of cracks (reinforced units)

Inspect any crack by means of a feeler gauge complying with the requirements of BS 957 : Part 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 $100 \pm 5^\circ\text{C}$ 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 $20 \pm 2^\circ\text{C}$.

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-immerses 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.

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 1200 mm (1000 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.

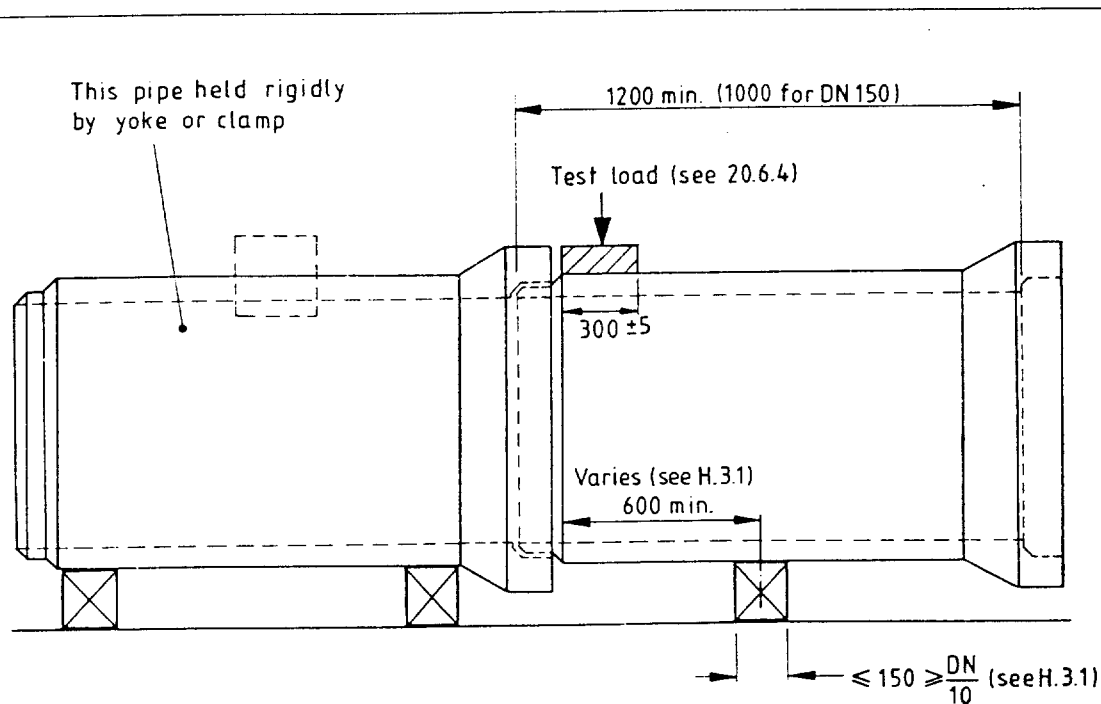
Reduce the pressure to just above atmospheric pressure and inspect the joint for signs of leakage.

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 electronic cover-measuring device in accordance with BS 4408 : Part 1 and suitably calibrated for size of reinforcement and curved surfaces where appropriate.

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 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.

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
Part 2 Metric units |
| BS 882 | Aggregates from natural sources for concrete |
| BS 903 | Methods of testing vulcanized rubber
Part A26 Determination of hardness |
| BS 957 | Specification for feeler gauges
Part 2 Metric units |
| BS 970 | Specification for wrought steels for mechanical and allied engineering purposes
Part 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
Part 108 Method for making test cubes from fresh concrete
Part 111 Method of normal curing of test specimens (20 °C method)
Part 116 Method for determination of compressive strength of concrete cubes
Part 120 Method for determination of the compressive strength of concrete cores |
| 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
Part 1 Specification for pulverized-fuel ash for use as a cementitious component in structural concrete |
| BS 4027 | Specification for sulphate-resisting Portland cement |
| BS 4408 | Recommendations for non-destructive methods of test for concrete
Part 1 Electromagnetic cover measuring devices |
| BS 4449 | Specification for hot rolled steel bars for the reinforcement of concrete |
| BS 4461 | Specification for cold worked 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
*Part 200 Specification for unreinforced and reinforced manholes and soakaways of circular cross section |
| 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
Part 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
Part 1 Code of practice for design and construction
Part 2 Code of practice for special circumstances |
| BS 8301 | Code of practice for building drainage |

* Referred to in the foreword only.

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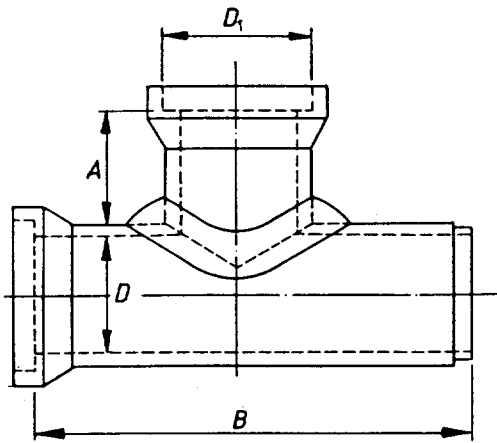
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Cement and Concrete Association
Cement Makers' Federation
Concrete Pipe Association
Concrete Society
County Surveyor's Society

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Department of Transport (Highways)
Federation of Civil Engineering Contractors
Glassfibre Reinforced Cement Association
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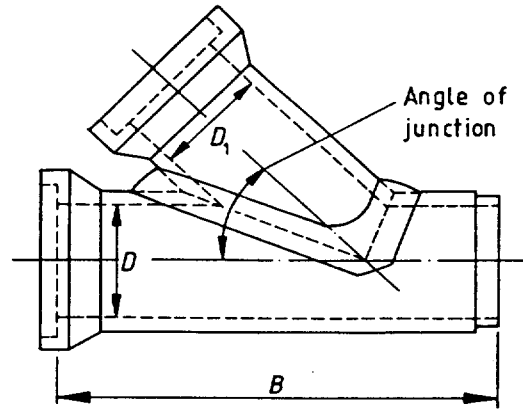
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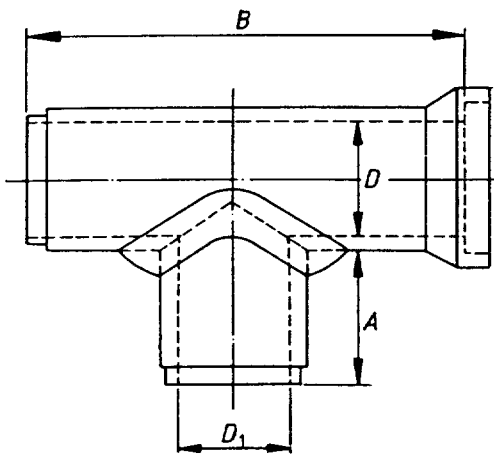
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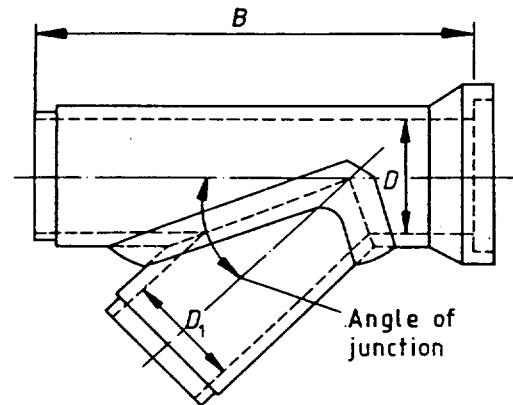
(a) Right-angled socket junction



(c) Oblique-angled socket junction



(b) Right-angled tumbling bay junction



(d) Oblique-angled tumbling bay junction

Figure 4. Typical junctions