
British Standard

Precast concrete pipes, fittings and ancillary products

Part 101. Specification for glass composite concrete (GCC) pipes and fittings with flexible joints

Tubes, accessoires et produits auxiliaires en béton préfabriqué

Partie 101. Tubes en béton armé et verre et accessoires à joints souples — Spécifications

Betonfertighre und -formstücke, und Nebenprodukte

Teil 101. Rohre und Formstücke aus glasfaserverstärktem Beton mit nachgiebigen Verbindungen

Foreword

This Part of BS 5911 has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee and covers centrifugally spun precast concrete pipes of composite construction strengthened by rovings of alkali-resistant glass fibre. With the publication of this standard, which the committee recommends is reviewed in three years' time because of the changing technology, DD 76 : Part 1 is withdrawn.

Guidance about concrete pipes incorporating glass rovings was first published by BSI in DD 76 : Part 1; it being adjudged that although this type of pipe was in service, the time was not then ripe for a full British Standard. A number of matters needed clarification supported by more user experience and technical data, particularly in respect of long term durability.

As in the case of conventionally reinforced pipes, the structural behaviour of composites depends on the proportion and disposition of the reinforcement. For example, current production of glass composite concrete (GCC) pipes is found to be satisfactory if an optimum quantity of certain types of glass fibre is included in each of two zones, one inner and one outer.

It is emphasized that the glass composite concrete used in the manufacture of pipes in accordance with this Part of BS 5911 differs from that used in spray-suction dewatered glass reinforced concrete (GRC) material in which the fibres are chopped rather than continuous, randomly arranged in the plane of the panels, and uniformly distributed throughout the thickness of the panels.

Rather than restrict the application of the standard by specifying particular designs and details of quantities and locations of the glass, control is exercised by specifying the strength of pipes before and after accelerated ageing.

Compared with the longevity of traditional concrete pipes, where the asset life is generally put at 80 years to 125 years, the performance of composites is more theoretical and frequently has to be extrapolated from test results. The 90-day accelerated ageing tests equate to about 25 years in use, though similar tests for much longer periods have shown GCC pipes to have a sensibly constant strength with time.

The BSI Technical Committee responsible for the standardization of precast concrete pipes wishes to acknowledge with thanks the submission, from many sources, of additional data on durability and other properties and the expert advice of research and user organizations.

Following a review of all data available, including work on fatigue resistance under heavy and varying loads, and on resistance to varying moisture and temperature conditions,

a decision was taken to proceed towards a British Standard based on the original work but up-dating it in the light of further knowledge. Because the product cannot be defined in terms of discrete items (e.g. the criteria governing the presence of the sand/cement mortar inner lining) and because research and development is on-going, the standard specifies the general characteristics and principal dimensions of the product together with certain performance requirements.

Compared with DD 76 : Part 1, amongst other things, the requirement for steam curing has been deleted and routine accelerated ageing tests at 15 days and 18 days have been added. These tests are considered equivalent to approximately 4 years and 5 years respectively in use of the pipes and are intended to provide a continuing check covering this period in the strength development of the pipe.

Conventional silicate glass compositions such as the 'E' glass used for the manufacture of fibres for the reinforcement of plastics are severely corroded in the highly alkaline environment of hydraulic cements. The development and experience with the type of pipe described in this standard has been based on the use of special alkali-resistant glass fibre formulations for which a British Standard is proposed. To ensure that the correct type of fibre is used, a test for alkali resistance has been included in appendix C.

The opportunity has been taken to align this specification with the 1988 revision of BS 5911 : Part 1 (now Part 100), including the provision of a bending moment resistance test.

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.

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 and 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.

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Section one. General

1 Scope

This Part of BS 5911 specifies requirements and describes methods of test for the manufacture of centrifugally spun precast concrete cylindrical pipes, bends and junctions with flexible joints, strengthened by rovings of alkali-resistant glass fibre, to be trench laid for the conveyance under atmospheric pressure of sewage or surface water, and for the construction of culverts. Such pipes are henceforth referred to as glass composite concrete (GCC) pipes. Requirements are given for materials, dimensions and inspection procedures.

NOTE. The titles of the publications referred to in this standard are listed on page 29.

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 pipe. A hollow cylinder manufactured from centrifugally spun concrete, cast as one piece and of uniform cross section throughout its length, except at the joint profile. The composite wall of each pipe contains rovings of alkali-resistant glass fibre, so positioned as to strengthen the concrete and in such quantities and distribution as to resist tensile stresses imposed by the specified test loads. The bore of the pipe is finished with an integral sand/cement mortar lining of sufficient thickness to cover the inner fibre rovings.

2.3 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.

2.4 manufacturing diameter. A diameter of a unit that a manufacturer seeks to achieve.

2.5 actual diameter. A diameter found by measurement.

2.6 effective length. The length of a pipe measured as shown in figure 1.

2.7 batch. The number of units of a particular specification produced under uniform conditions during a given production period by one particular process.

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 101*;
- (b) an indication that the unit is strengthened by rovings of glass, which shall consist of the letter 'G';
- (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 20.3.1);
- (d) the letter 'S', where sulphate-resisting Portland cement has been used;

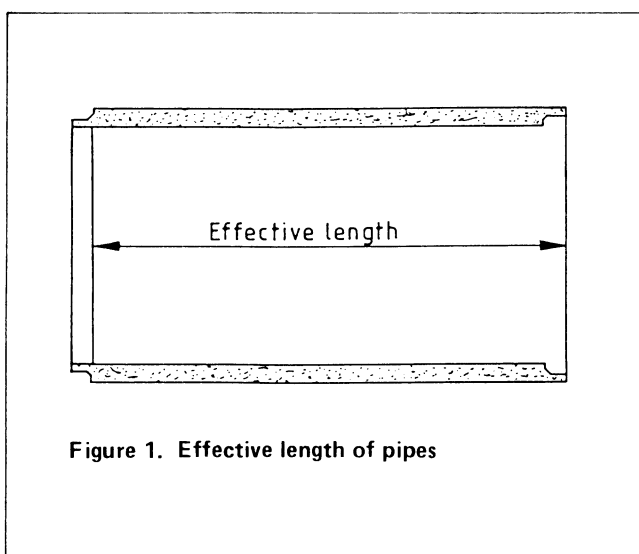


Figure 1. Effective length of pipes

* Marking BS 5911 : Part 101 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. 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.

- (e) the letter 'A', where an admixture has been used;
- (f) the day, month and year of manufacture;
- (g) the manufacturer's mark and works identification mark;
- (h) where tests, as specified in **20.1**, **20.2** and **20.3.2**, 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 (h), 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.

NOTE. Examples of marking

1. 'C' 'X'
BS 5911 : Part 101 'G M S A'
2.5.88
'Hyd' 'Z'

The above marking on a GCC pipe would signify:

'Claimed by manufacturer 'C' to have been made at his works 'X' and to comply with BS 5911 : Part 101; to be strengthened by rovings of alkali-resistant glass; to be of class M and made with sulphate-resisting cement; to contain an admixture in the

concrete; to have been made on 2 May 1988, and to have been successfully tested hydrostatically, as specified in **20.2**, with results recorded in the manufacturer's quality control records 'Z'.'

2. 'D' 'Y'
BS 5911 : Part 101 'G' 240/300
3.6.88
'Proof' 'T'

The above marking on a GCC pipe would signify:

'Claimed by manufacturer 'D' to have been made at his works 'Y' and to comply with BS 5911 : Part 101; to be strengthened by rovings of alkali-resistant glass; to be made to resist works proof and maximum crushing test loads of 240 kN 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 **20.3.2**, with results recorded in the manufacturer's quality control records 'T'.'

3.2 Method of marking

Units shall be marked with either:

- (a) indelible paint, applied by stencil brush or spray as soon as possible after removal from the mould; or
- (b) impressed characters approximately 2 mm deep.

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

Section two. Materials

4 Cement

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

Type of cement	Standard to be complied with
ordinary or rapid-hardening Portland	BS 12
sulphate-resisting Portland	BS 4027

NOTE. The minimum cement content and maximum water/cement ratio specified in 7.1 will ensure that either of the permitted cements will facilitate resistance to sulphate attack equivalent to classes 1 and 2 of table 6.1 of BS 8110 : Part 1 : 1985. Class 3 resistance will be provided by the use of cement in accordance with BS 4027 alone, which 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.

5 Aggregates and sand

5.1 General

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

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

Sand for mortar shall comply with BS 1200 : 1976 graded in accordance with table 1 of that standard.

5.2 Testing

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

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

- (a) 20 mm;
- (b) one-quarter of the minimum thickness of the unit.

6 Other concrete materials

6.1 Water

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

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

6.2 Admixtures

Admixtures shall comply with BS 5075 and shall not be used in the sand/cement mortar lining to the bore.

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

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 concrete made with cement complying with BS 4027.

The manufacturer shall make available details of:

- (a) the relevant production records;
- (b) the admixture(s) used;
- (c) the dosage rate of each admixture;
- (d) the effect of under- and over-dosing.

7 Concrete mix, casting and finish

7.1 Cement content

The fully compacted concrete shall contain not less than 360 kg of cement per cubic metre and shall have a water/cement ratio not greater than 0.35.

7.2 Chloride content

The total chloride ion content of the concrete mix, where this incorporates cement complying with BS 4027, shall not exceed 0.2 % by mass of the cement.

7.3 Work in cold weather

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

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

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

7.4 Compaction

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

7.5 Surface regularity

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

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

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

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

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

Where glass fibres are exposed, the surface shall be made good using material complying with 7.6.1.

7.6 Making good

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

- (a) Neat cement grout, with or without the addition of styrene-butadiene rubber (SBR), the type of cement being compatible with that in the unit to be made good.
- (b) 1:3 cement/sand mortar proportioned by mass with or without the addition of SBR. The cement shall be compatible with that in the unit to be made good and the sand shall comply with the requirements for fine aggregate in BS 882 but have a grading such that 100 % of the material passes a 5 mm sieve.
- (c) A sample of the concrete mix minus the coarse aggregate retained on the 5 mm sieve, with or without the addition of SBR.
- (d) Epoxy or polyester resin, or polymer latex mortar.

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

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

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

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

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

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

- (1) In any unit the total exposed area of broken concrete shall not exceed $6 \times (DN) \text{ mm}^2$ 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 (b) (2) shall not apply.

7.6.4 Rubbing down. After a unit has been cured and prior to despatch, it is permissible to rub down where necessary to produce a surface regularity complying with 7.5.

8 Glass rovings

The rovings of alkali-resistant glass shall be distributed throughout the length of the pipe and be free from oil, grease and other contamination.

The diameter of the glass fibres in the rovings shall be in the range $8.0 \mu\text{m}$ to $25.0 \mu\text{m}$.

The rovings shall be sampled and tested for roving count, loss on ignition and alkali-resistance as described in appendix C, and shall be within the appropriate limits given in table 1.

Table 1. Limits and frequency of testing for glass rovings		
Property	Limits	Minimum frequency of testing
Roving count (Tex) (see C.1)	$\pm 10 \%$ from nominal value stated by supplier	Each 500 kg*
Loss on ignition (see C.2)	$\pm 20 \%$ from nominal value stated by supplier or ± 0.2 from the nominal value, whichever is the greater tolerance (see note)	Each 20 000 kg*
Strength retention by strand-in-cement test (see C.3)	Minimum value 330 MPa after $96 \pm 1 \text{ h}$ in water at $80 \pm 1 ^\circ\text{C}$	Each 50 000 kg
* These test frequencies are consistent with those for normal grade in table 1 of BS 3691 : 1969. NOTE. For example, if the nominal value of the ignition loss is 1.5 %, the alternatives will be $\pm 20 \%$ of 1.5 %, i.e. $\pm 0.3 \%$, or ± 0.2 in 1.5, i.e. $\pm 0.2 \%$ The $\pm 0.3 \%$ tolerance will apply being the greater.		

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

† Obtainable from C & C A, Wexham Springs, Slough, Bucks SL3 6PL.

Section three. Dimensions and tolerances

9 Nominal size and effective length

9.1 Nominal size (DN)

The nominal sizes (see 2.3) of units shall be either:

- (a) those shown in column 1 of table 2; or
- (b) for pipes in the range DN 1200 to DN 1800, 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 2.6) 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 2.4) 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 2.5) shall not deviate from the manufacturing diameter by an amount greater than that given in column 3 of table 2.

11 External manufacturing diameter

The external manufacturing diameter of the barrel of a unit (see 2.4) 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.

Table 2. Nominal sizes and tolerances for units (see 9.1(b))

1	2		3	4
Nominal size of units DN (see 9.1)	Limits of internal manufacturing diameter (see clause 10)		Deviation of actual internal diameter from internal manufacturing diameter (see clause 10)	Variation of wall thickness (see clause 12)
	Maximum diameter	Minimum diameter		
	mm	mm	mm (±)	mm
150	155	150	5	6
225	230	225	5	6
300	305	300	5	6
375	385	365	6	6
450	460	440	6	6
525	535	515	6	6
600	610	590	6	6
675	695	655	6	6
750	770	730	6	6
825	845	805	6	6
900	920	880	6	6
975	995	955	6	6
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

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 D, 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 concrete, within the limit specified in 20.3.2, as a result of testing in accordance with appendix E;

- (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 rebated type. They shall be designed to incorporate an elastomeric ring complying with type D of BS 2494. A joint assembly shall be tested as specified in 20.4 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 1. For a typical joint, see figure 2.

NOTE 2. Joints for branch pipes of junctions will normally be of the flexible type, unless otherwise required. See clause 18.

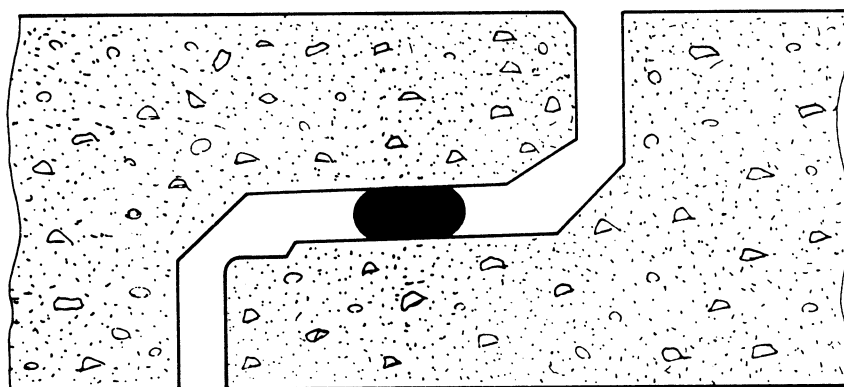


Figure 2. Typical flexible joint

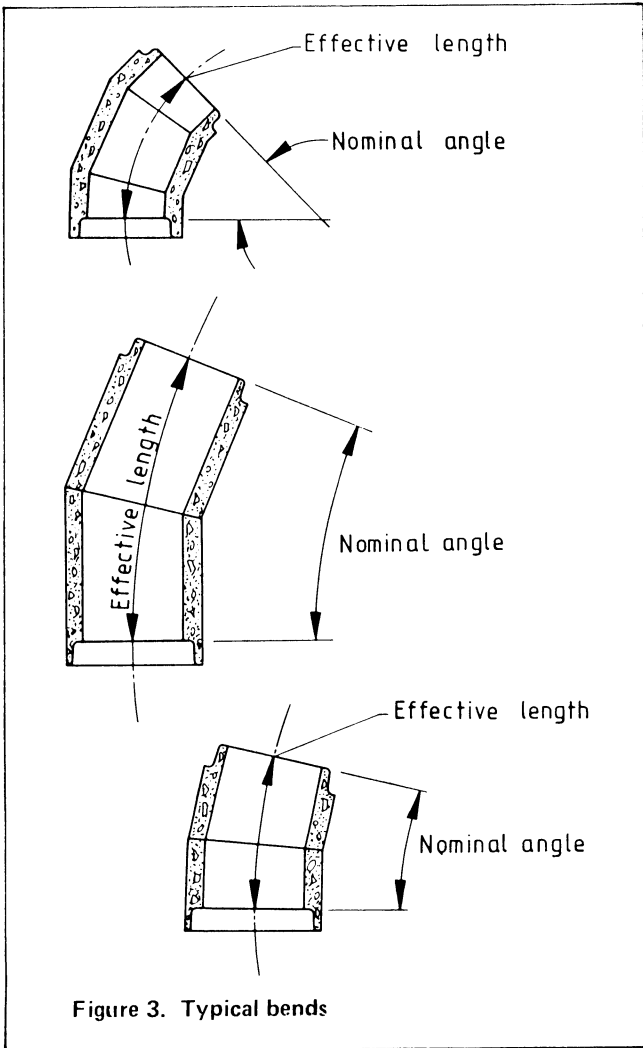
17 Bends

Bends shall be 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 shown in table 3 for the appropriate nominal angles of bend.

Table 3. Minimum effective lengths and nominal angles for bends		
Nominal size DN	Nominal angles	Minimum effective length
	degrees	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 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 built up by inserting a branch pipe in the main GCC pipe. GCC 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 compatible 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 3. Junctions may not necessarily have the same load-bearing capacity as the pipes with which they are to be laid.