TRRL Application Guide 2

**Transport
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Department of Transport

The structural design and laying of small underground drains of rigid materials

by O C Young

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TRANSPORT AND ROAD RESEARCH LABORATORY
Department of Transport

APPLICATION GUIDE 2

THE STRUCTURAL DESIGN AND LAYING OF SMALL UNDERGROUND DRAINS OF RIGID MATERIALS

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THE STRUCTURAL DESIGN AND LAYING OF SMALL UNDERGROUND DRAINS OF RIGID MATERIALS

ABSTRACT

Factors affecting the choice of different types of pipes of rigid materials for use in small underground drains or sewers are discussed. Various methods of bedding them are described, with their merits and limitations, and tables are included giving the range of permissible cover depths for the various pipes when laid on these beddings.

1 INTRODUCTION

This report is intended as a convenient guide mainly for those having to design and specify underground drainage systems for jobs that do not justify detailed calculations, and is limited to pipes up to 300 mm nominal diameter. Only pipes of rigid materials are discussed; for pipes of flexible materials reference may be made to TRRL Supplementary Report 375. (Young 1978). For sizes above 300DN* and for more detailed information the TRRL report 'A guide to design loadings for buried rigid pipes' (Young and O'Reilly, 1983) may be consulted. A set of revised 'Simplified tables' (Young, Brennan and O'Reilly) is also in preparation.

The estimation of maximum flows and the choice of pipe diameters and gradients are dealt with in building regulations (Statutory Instruments, 1976) and codes of practice (British Standards Institution, 1985, 1968) and they are not considered here.

The present report was first published in 1977 as TRRL Supplementary Report 303 (Young, 1977) but since then pipe standards have been altered, and the above-mentioned guide (Young and O'Reilly, 1983) has been published, in which some changes in the way the effects of surcharge loadings are calculated, have been advocated. These developments have made a revision of the 1977 report necessary, although in practical terms the total effects are small. Changes in crushing test strengths in the new standards arise mainly from a rounding of figures following a change of units from kgf/m to kN/m. Changes in the pipe loading due to surcharges, arising from change of method, are only slight for pipes up to 300DN. Small changes in the mode of presentation of the information in the report have also been made.

2. GENERAL CONSIDERATIONS

2.1 ASSESSMENT OF PIPE ENVIRONMENT

Before deciding on pipe material, method of jointing and method of bedding the pipes, it is necessary to consider the conditions to which the pipeline will be exposed. In particular it is vital to know the general composition of the liquids likely to be carried by the pipeline and their probable temperature, the nature of the ground in which the pipeline is to be laid, and the extent to which parts of the line may be subjected to movement after construction. The possibility of contractors' heavy equipment operating over the line after it has been constructed, particularly before the road pavement has been constructed, must also be borne in mind. These aspects are considered in more detail below.

2.2 CHEMICAL ATTACK

2.2.1 Resistance of pipes and joints to attack

All the types of pipe listed in this report, and the joints and rings supplied by the manufacturers, are resistant to the substances normally found in domestic sewage and in general to wastes considered acceptable for discharge into a biological sewage treatment plant or a river. In cases of doubt, advice should be sought from the manufacturer or pipe association (See references). Some waste discharges may be aggressive to the pipe material or to components of the joints. Sulphates or acids present in the soil or ground water, or produced through the generation of hydrogen sulphide in septic sewage, can be aggressive to pipes made from Portland cement. Guidance as to the factors responsible for sulphate attack on concrete below ground and methods of resisting this attack are given in Building Research Establishment Digest 174 (Building Research Establishment, 1975). Sulphate-resisting cement gives greater resistance to sulphate attack, but not necessarily to acid attack. Particular care is needed on sites where dumping has taken place, as injurious substances in the dumped material can cause the ground water to become aggressive. If the pipes have a protective coating, damage to the coating should be avoided. Any damage should be made good as soon as possible, and checked before the pipeline is covered up. Some soils (eg peaty soils) may contain acids, and in others sulphate-reducing bacteria can produce acids. These acids, acting through weaknesses in the coating, can cause local perforation of the pipe wall. The risk of such attack can be greatly reduced by the use of loose polyethylene (polythene) sleeving drawn over the pipeline (Andrews, 1975).

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* DN denotes nominal diameter in mm.

2.2.2 Rubber jointing rings

The rubber rings normally supplied for the manufacturers' flexible joints are resistant to attack by most acids or alkalis in the concentrations likely to occur, but could be affected by other substances in trade wastes, such as certain oils, organic solvents or copper salts. Rubber rings are usually specified to be to BS 2494:1976. This standard now covers rings of various synthetic rubbers as well as natural rubber, and each material has properties rendering it more suited or less suited to a particular use.

2.2.3 Aggressive liquids

In all cases where the pipeline is liable to carry liquids containing other than purely domestic drainage or surface water, it is advisable to seek advice from the manufacturer or trade association (See references) as to the possible effect on the pipe, the rubber ring or any associated jointing components or pipe coatings. It is important to state the nature of the substances contained in the liquids, their probable maximum concentration and temperature.

2.3 PIPELINE FLEXIBILITY

2.3.1 Flexible joints

Most (but not all) pipes are now supplied with manufacturers' flexible joints. These, besides providing for rapid assembly, also allow movement to take place between adjoining pipes. Such movement can arise from settlement of the soil, shrinkage or expansion of clay soils with changes in their moisture content, differential settlement of structures to which the pipeline is connected, or from mining subsidence. Where the continued watertightness of the pipeline is considered important, the use of such joints is strongly recommended. If the jointed pipes are not in line when laid the flexibility available to cope with movement will be restricted.

2.3.2 Joints for aggressive liquids

A difficulty may arise where the manufacturer's normal joint is not suitable for use with the liquid being carried. In such cases it may be necessary to employ spigot and socket or double collar joints caulked with special jointing compound. Such joints are likely to provide only very limited flexibility. Depending on the amount of anticipated movement various expedients may be adopted to minimise the risk of fracture; specially short pipes may be used, or the pipeline laid on a continuous, extra thick bedding of in-situ concrete reinforced longitudinally with steel top and bottom to minimise transverse cracking, or the whole pipeline may be laid inside a duct, with provision for access. Special consideration should be given to places where a concentration of movement is likely, eg at connections to buildings. Provision of easy access to such points for inspection and repair is a wise precaution.

2.3.3 Jointing of cut pipes

Flexible joints provided by some manufacturers cannot be used to join cut pipes. Manufacturers can often supply pipes shorter than standard length, but cutting to provide a make-up length is sometimes unavoidable, and some kind of caulked joint or proprietary coupling must be used. In such cases the length of pipeline containing the caulked joint between two normal flexible joints should not exceed that of a standard pipe length. Where pipes are laid on a Class A concrete bedding this provision does not apply, but construction joints should be formed in the concrete at intervals not exceeding 5 m. They must be at a flexible joint.

2.3.4 Provisions where drains connect to manholes and other structures

The projecting length of pipes built into manholes or other structures should be kept as short as practicable; the projection should not exceed about two pipe diameters. Where a structure is on piles extending through made-up ground the underground drains are liable to settle more than the structure. In other conditions the reverse may occur. In all such cases careful attention to detail is needed at places where pipes pass out of the structure into the ground. Where an appreciable amount of differential movement is anticipated the projection of the pipe outside the structure should be restricted to about 150 mm. The next pipe should be kept short, say 0.6 m length. The two flexible joints spaced at 0.6 m can then act as a pair of 'hinges'. Depending on the amount of expected movement, it may also be advisable to locate this pipe inside a length of larger pipe to provide protection against excessive soil pressures resulting from the settlement. The ends must be suitably blocked to prevent the ingress of soil into the annular space. If there are several vertical stacks making connection to horizontal runs beneath the structure, it is often simplest where practicable to make these runs integral with the structure so that drains and structure settle as one; the special provision against movement then only needs to be made where the drains finally pass out of the structure.

2.3.5 Jointing

Joints should always be assembled strictly in accordance with the manufacturer's instructions. Cleanliness of the mating surfaces is essential, and where a lubricant is specified only that recommended should be used. There is little evidence that the penetration of soil into the outer part of the annular gap constitutes a hazard to flexibility. Pipes should be properly aligned when installed, so that the maximum amount of joint movement is made available to cope with future settlement. Where in-situ concrete is used for bedding, 12 mm wide vertical gaps should be formed in the concrete at spacings dependent on the amount of ground movement likely to occur but, in any case, not greater than 5 m. The gaps must be in line with the socket ends, and may be readily formed from polystyrene cut to fit around the spigots and touching the end faces of the sockets.

2.3.6 Maximum pipe length

Although the use of flexible joints greatly reduces the risk of fracture from differential settlements along the length of the pipeline, such settlements can in some circumstances still occur within the length of a single pipe, so causing the pipe to act as a beam. This is particularly so in the case of pipes having a length/diameter ratio of 8 or more. Whilst pipes having a length/diameter ratio of 8 or more have performed satisfactorily in most cases, careless bedding or instability of support arising from various factors has been known to cause fractures. In cases of doubt advice should be sought from the manufacturers or pipe association (See references).

2.4 CONSTRUCTION TRAFFIC

The passage of contractors' heavy plant over trenches may cause heavier loadings on the pipes than are allowed for in Tables 1 to 3, especially at shallow cover depths (Young and O'Reilly, 1983. Trott and Gaunt, 1976). Suggested precautions are:

a) For the 'fields' loadings, the passage of vehicles having wheel loads over 30 kN (3.2 tonne) across the pipeline should be restricted to special crossing places provided with bridges. If this cannot be enforced, design to a heavier category of loading is advisable.

b) For 'main roads' and 'light roads' loadings, where heavy vehicles will operate over the ground surface after the pipes have been laid but before the road pavement has been constructed, and where such traffic cannot be restricted to special bridge crossings, the design should be based on the cover depth that will exist at that time. (This cover depth could typically be 0.4 m less than the final cover depth).The load imposed on the pipeline increases very rapidly with diminishing cover depth.

2.5 COMBINED TRENCHES

It is sometimes the practice to instal more than one pipeline in a single trench. The laying depths in Tables 1, 2 and 3 will apply to the individual pipes, provided the depths shown in brackets (see Section 7.3) are not used. For more information see Young and O'Reilly (1983).

Where pipelines are at different depths the upper pipe is often laid on a step in the trench. This practice should be adopted only where ground conditions are sufficiently stable to ensure that the step will not break away. If this should happen the support for the upper pipe is very likely to become uneven, with the risk that individual pipes will suffer beam breakage. (see also 2.3.6). To decrease the risk, special care should be taken to compact the sidefills very thoroughly up to at least the horizontal diameter of the upper pipe. If ground conditions are uncertain it is better not to use a stepped trench.

3 CHOICE OF PIPES

The main types of rigid pipes currently available are briefly described below.

3.1 CLAY PIPES

BS 65: 1981. Vitrified clay pipes, fittings and joints.

Clay pipes are resistant to attack by a wide range of substances, both acid and alkaline, but some substances, such as organic solvents, could affect the plastics material and rubber rings used for the flexible joints. The manufacturers or their Association (Clay Pipe Development Association Ltd) will advise in cases of doubt.

3.2 CONCRETE PIPES

BS 5911: Part 1: 1981. Precast concrete pipes and fittings for drainage and sewerage.

Concrete pipes are available in sizes from 150 DN upwards. The liability to chemical attack has been discussed in 2.2.1. Proprietary coatings are available for internal or external protection.

3.3 ASBESTOS-CEMENT PIPES

BS 3656: 1981. Asbestos-cement pipes and fittings for sewerage and drainage.

The liability to chemical attack has been discussed in 2.2.1. Pipes dipped in bitumen at the works are available if so ordered, and the coating provides increased resistance to attack.

3.4 IRON PIPES

BS 4622: 1970. Grey iron pipes and fittings

BS 4772: 1971. Ductile iron pipes and fittings

The liability to chemical attack has been discussed in 2.2.1. Pipes are usually supplied with a factory-applied protective coating. Care should be taken not to damage it in handling, but any damage sustained should be made good before laying.

Iron pipes are not usually employed for gravity-flow pipelines below ground but are useful where their high strength is an advantage, eg in difficult water-logged ground, where large ground movements are expected or at very shallow depths under roads. Pipes to BS 4772 have the additional advantage of ductility, making them better able to meet the above adverse conditions. Iron pipes are also used in pumped systems, but for such conditions of combined internal pressure and external load consult reference. (Young and O'Reilly, 1983). Iron pipes are not included in Tables 1, 2 and 3 because their crushing strengths are sufficiently high to permit their use at all depths and on all of the beddings covered by the tables in the report. Because of their greater length/diameter ratio the main risk to ordinary

(Continued on page 7)

TABLE 1

Minimum and maximum cover depths for pipes laid under main roads

'Main roads' means roads intended to carry the heaviest types of road vehicles (see Section 7).
N.B. For explanatory notes on tables see Section 7.3
* The bracketted depths relate to the trench widths given at the top of the column (see Section 5.2)

PIPE NOMINAL DIA.	100					150					225					300				
ASSUMED TRENCH WIDTH IN METRES*	—					0.6					0.7					0.85				
BEDDING CLASS	D or N	F	B	S	A	D or N	F	B	S	A	D or N	F	B	S	A	D or N	F	B	S	A
CLAY Standard strength min. depth max. depth	0.7 3.6	0.6 5.5	a	b	b	x	0.7 3.3	0.6 4.6	0.6 5.6	a	x	x	0.9 2.4	0.7 3.3 (5.4)	0.6 4.2 (>6.0)	x	x	x	1.1 1.9	0.8 3.0 (4.1)
Extra strength min. depth max. depth	0.6 4.2	a	b	b	b	1.1 2.0	0.6 3.8	0.6 5.2	a	b	x	0.8 3.0 (3.8)	0.6 4.3 (>6.0)	0.6 5.3 (>6.0)	a	x	1.0 2.3	0.7 3.7 (>6.0)	0.6 4.5 (>6.0)	0.6 5.6 (>6.0)
Super strength min. depth max. depth	0.6 5.6	a	b	b	b	0.7 3.4	0.6 5.2	a	b	b										
CONCRETE Class L min. depth max. depth						0.8 2.8	0.6 4.5 (>6.0)	a	b	b	x	1.0 2.3	0.7 3.7 (>6.0)	0.6 4.5 (>6.0)	0.6 5.6 (>6.0)	x	x	1.2 1.8	0.8 2.8 (3.4)	0.6 3.7 (>6.0)
Class M min. depth max. depth																x	x	0.8 2.8 (3.4)	0.7 3.6 (>6.0)	0.6 4.6 (>6.0)
ASBESTOS-CEMENT Class M min. depth max. depth																x	0.8 3.1	0.6 4.5 (>6.0)	0.6 5.4 (>6.0)	a
Class H min. depth max. depth	a	a	b	b	b	0.6 5.2	a	b	b	b	0.7 3.4 (4.0)	0.6 5.2 (>6.0)	a	b	b	0.8 3.0 (3.7)	0.6 4.8 (>6.0)	a	b	b

TABLE 2

Minimum and maximum cover depths for pipes laid under light roads

'Light roads' means roads other than those covered by Tables 1 and 3 (see Section 7).
N.B. For explanatory notes on tables see Section 7.3.
* The bracketted depths relate to the trench widths given at the top of the column (see Section 5.2)

PIPE NOMINAL DIA.	100					150					225					300				
ASSUMED TRENCH WIDTH IN METRES*	—					0.6					0.7					0.85				
BEDDING CLASS	D or N	F	B	S	A	D or N	F	B	S	A	D or N	F	B	S	A	D or N	F	B	S	A
CLAY																				
Standard strength																				
min. depth	0.7	0.6	a	b	b	1.1	0.7	0.6	0.6	a	x	1.2	0.9	0.7	0.6	x	x	1.2	0.9	0.7
max. depth	4.1	5.8				2.5	3.8	5.0	5.8			2.1	3.2	3.8	4.6				2.9	3.6
		(>6.0)					(4.2)	(>6.0)	(>6.0)				(4.0)	(>6.0)	(>6.0)			2.3	(3.5)	(5.6)
Extra strength																				
min. depth	0.6	a	b	b	b	0.9	0.6	0.6	a	b	1.2	0.8	0.6	0.6	a	x	0.9	0.7	0.6	0.6
max. depth	4.6					2.9	4.2	5.5			2.2	3.6	4.7	5.5			3.1	4.2	4.9	5.9
							(>6.0)	(>6.0)				(5.9)	(>6.0)	(>6.0)			(4.0)	(>6.0)	(>6.0)	(>6.0)
Super strength																				
min. depth	0.6	a	b	b	b	0.7	0.6	a	b	b										
max. depth	5.9					3.9	5.5													
						(4.8)	(>6.0)													
CONCRETE																				
Class L																				
min. depth						0.8	0.6	a	b	b	x	0.9	0.7	0.6	0.6	x	x	1.0	0.8	0.7
max. depth						3.4	4.9					3.1	4.2	4.9	5.9			2.8	3.4	4.2
							(>6.0)					(3.9)	(>6.0)	(>6.0)	(>6.0)			(3.3)	(4.9)	(>6.0)
Class M																				
min. depth																x	1.1	0.8	0.7	0.6
max. depth																	2.4	3.5	4.1	4.9
																		(5.0)	(>6.0)	(>6.0)
ASBESTOS-CEMENT																				
Class M																				
min. depth																1.1	0.7	0.6	0.6	a
max. depth																2.4	3.7	4.9	5.7	
																	(>4.4)	(>6.0)	(>6.0)	
Class H																				
min. depth	a	a	b	b	b	0.6	a	b	b	b	0.7	0.6	a	b	b	0.8	0.6	a	b	b
max. depth						5.5					3.9	5.5				3.6	5.1			
						(>6.0)					(5.7)	(>6.0)				(5.0)	(>6.0)			

TABLE 3

Minimum and maximum cover depths for pipes laid under fields etc

'Fields etc' includes gardens and lightly trafficked access tracks (see Section 7).
N.B. For explanatory notes on tables see Section 7.3.
* The bracketted depths relate to the trench widths given at the top of the column (see Section 5.2)

PIPE NOMINAL DIA.	100					150					225					300				
ASSUMED TRENCH WIDTH IN METRES*	—					0.6					0.7					0.85				
BEDDING CLASS	D or N	F	B	S	A	D or N	F	B	S	A	D or N	F	B	S	A	D or N	F	B	S	A
CLAY Standard strength min. depth max. depth	0.6 4.2	0.6 5.8	a	b	b	0.6 2.7	0.6 3.9 (4.6)	0.6 5.0 (>6.0)	0.6 5.9 (>6.0)	a	x	0.7 2.5	0.6 3.3 (4.3)	0.6 3.9 (>6.0)	0.6 4.7 (>6.0)	x	0.9 1.7	0.6 2.5 (2.7)	0.6 3.1 (3.7)	0.6 3.7 (5.7)
Extra strength min. depth max. depth	0.6 4.7	a	b	b	b	0.6 3.1	0.6 4.3 (>6.0)	0.6 5.5 (>6.0)	a	b	0.6 2.5	0.6 3.7 (>6.0)	0.6 4.8 (>6.0)	0.6 5.6 (>6.0)	a	0.7 2.2	0.6 3.3 (4.2)	0.6 4.2 (>6.0)	0.6 5.0 (>6.0)	0.6 5.9 (>6.0)
Super strength min. depth max. depth	a	a	b	b	b	0.6 4.0 (5.1)	0.6 5.6 (>6.0)	a	b	b										
CONCRETE Class L min. depth max. depth						0.6 3.5	0.6 5.0 (>6.0)	a	b	b	0.8 2.2	0.6 3.2 (4.1)	0.6 4.2 (>6.0)	0.6 4.9 (>6.0)	0.6 5.9 (>6.0)	x	0.7 2.2	0.6 3.0 (3.6)	0.6 3.6 (5.1)	0.6 4.3 (>6.0)
Class M min. depth max. depth																1.0 1.6	0.6 2.7 (2.9)	0.6 3.6 (5.1)	0.6 4.2 (>6.0)	0.6 5.0 (>6.0)
ASBESTOS-CEMENT Class M min. depth max. depth																0.6 2.6	0.6 3.8 (4.5)	0.6 4.9 (>6.0)	0.6 5.7 (>6.0)	a
Class H min. depth max. depth	a	a	b	b	b	0.6 5.5 (>6.0)	a	b	b	b	0.6 4.0 (6.0)	0.6 5.5 (>6.0)	a	b	b	0.6 3.7 (4.3)	0.6 5.2 (>6.0)	a	b	b

grey iron pipes is of beam breakage, care should therefore be taken to ensure uniformity of support along the length of individual pipes.

4 CHOICE AND METHOD OF BEDDING

4.1 GENERAL CONSIDERATIONS

The various methods of bedding pipes are shown below in decreasing order of strength and their advantages and limitations discussed. There is often a choice between the use of a high strength pipe on a weak bedding or vice versa. The choice is dependent on factors such as overall economy, site conditions and material availability. With small jobs where it is often difficult to ensure effective supervision of bedding it is preferable to choose a pipe requiring minimum bedding support. However, Class D bedding does demand a high standard of workmanship and supervision. In all cases it is important that pipes should not rest on blocks or similar hard packings.

4.2 CLASS A BEDDING—CONCRETE CRADLE (see Figure 2)

This bedding may be needed to provide the necessary strength. Other reasons for its use are:

(1) where accuracy of pipe gradient is important; with other beddings some small settlement after laying is to be expected,

(2) where it is impracticable to remove the trench sheeting until after completion of the bedding,

(3) to minimise disturbance to the pipeline by future excavations alongside it,

(4) to minimise the risk to adjacent foundations

Disadvantages are:

(1) the need to control the quality, placing and compaction of the concrete, particularly in wet conditions,

(2) the need for special precautions in frosty weather,

(3) the delay that arises through having to allow the concrete to harden before further backfilling,

(4) even allowing for the saving due to using a pipe of reduced strength, the overall cost is likely to be higher than with granular bedding.

Concrete should be spread over the trench bottom, to a thickness that will just clear the sockets, and be properly compacted. Two ways of laying the pipes are recommended:

a) Pipes light enough to manhandle can be placed on a strip of freshly mixed concrete the length of the pipe barrel laid on the concrete base as soon as this has set sufficiently. The pipes are gently tapped down to the correct level. The consistency of the concrete needs careful control; if too stiff excessive force will be needed to grade the pipes correctly; if too wet the pipes may continue to settle.

b) Alternatively the pipes can be supported at the correct level on pairs of small folding timber wedges

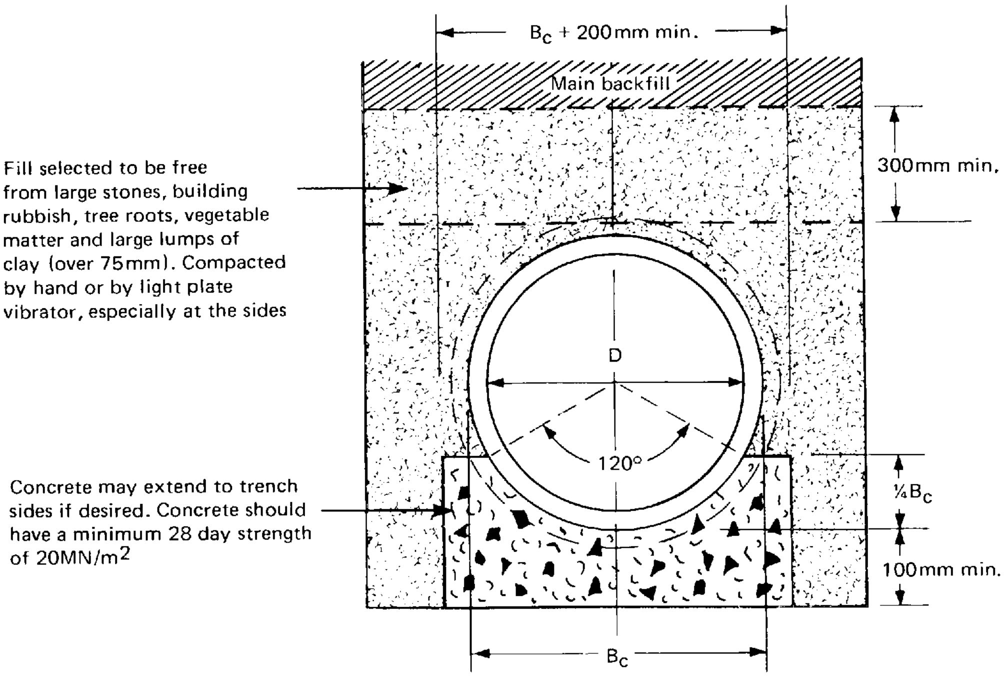

Fig. 2 Class 'A' Bedding Concrete cradle

placed behind each socket (or both sides of the coupling in the case of double-spigot pipes). The wedges should be kept as small as practicable, and preferably wet to minimise possible ill-effects of swelling.

Whichever method is used care must be taken to keep the top surface of the concrete bed clean, to ensure a good bond to the haunch concrete which, after testing the pipeline, should be placed and compacted as soon as possible. Concreting should be completed within 45 minutes of mixing.

A 150 mm layer of fill may be placed over the pipes for protection, but the pipeline should not be subjected to additional load or vibration until the concrete has acquired sufficient strength, say at least 24 hours after concreting. Heavy rammers should not be used nor traffic loads permitted for at least 72 hours, or longer in cold weather (Department of the Environment, 1960).

4.3 GRANULAR BEDDINGS (see Figure 3)

4.3.1 Class S bedding—360° surround

This bedding requires greater quantities of granular material than a Class B bedding and is used where the excavated soil is unsuitable for backfilling around the pipe without careful selection.

For the design of pipes in trenches that are wider than those tabulated (irrespective of depth) and for the uppermost pipe in stepped combined trenches, the strength of this bedding should be taken as the same as Class B. Where the bottom of the trench is below the water table movement of water along the trench is likely, particularly when the gradient is steep. Such water may appear at the ground surface lower down the pipeline and measures to inhibit the flow, such as clay or lean-mix water stops at manholes or inspection chambers, are necessary. In fine-grained soils the water may have a softening effect resulting in more than average settlement of the pipeline and appropriate precautions to avoid damage to the pipeline should be taken (2.3.6).

In wet fine-grained soils the migration of fine soil particles into the voids of the bedding may be minimised by surrounding the granular material with filter fabric.

As an alternative to the BS 882 materials specified, material having a Compaction Fraction value (see Appendix) not exceeding 0.15 may be used.

4.3.2 Class B bedding—180° support

The advantages of this bedding lie in its reliability, ease and speed of construction, and in the uniformity of support afforded to the pipe. A disadvantage is the need for selected granular material. See also 4.3.1 regarding settlement and provision of waterstops.

As an alternative to BS 882 aggregates, material with a Compaction Fraction value not greater than 0.30 may be used. Materials with C.F. value between 0.15 and 0.30 require progressively more care in their placement and compaction, to ensure reasonably uniform support along the pipe length, particularly with pipes of length/diameter ratio exceeding 8.

4.3.3 Class F bedding—flat granular layer

The advantage of this bedding is that it uses less granular material than Classes S and B whilst avoiding some of the problems likely to be encountered with Class D. The granular layer should be placed, compacted and levelled with its surface a little on the high side, so that during laying the pipe digs in slightly to give the specified invert level and gradient for the pipeline.

See also 4.3.1 regarding waterstops and precautions in wet soil conditions.

4.3.4 Class N bedding—flat granular layer

This bedding is similar to Class F except that all-in aggregate or sand is used in place of the single-size material and the supporting strength of the bedding is reduced. As an alternative to the BS 882 material indicated in Figure 3, material with a C.F. value not greater than 0.30 may be used (see Appendix). The flat layer of material should be well compacted to the correct height to support the barrel of the pipe as uniformly as possible. See also 4.3.1 regarding waterstop and precautions in wet soil conditions.

4.4 CLASS D BEDDING—TRIMMED TRENCH BOTTOM (see Figure 4)

This method is suitable only where accurate hand trimming of the trench bottom by shovel is possible. A high standard of supervision is essential.

The trench should be excavated slightly shallower than required so that hand trimming brings the bottom to the correct level. Over-dug places should be levelled up by thoroughly tamping in fill. Hard packings, such as timber or bricks, under the pipes should be prohibited.

Class D bedding should not be used in the following types of ground

Type I*	Rock that requires a mechanically operated pick for excavation.
Type II*	Compact sand or gravel requiring a pick for excavation. If it is difficult to drive a 50 mm square wooden peg deeper than 150 mm, the conditions are unsuitable.

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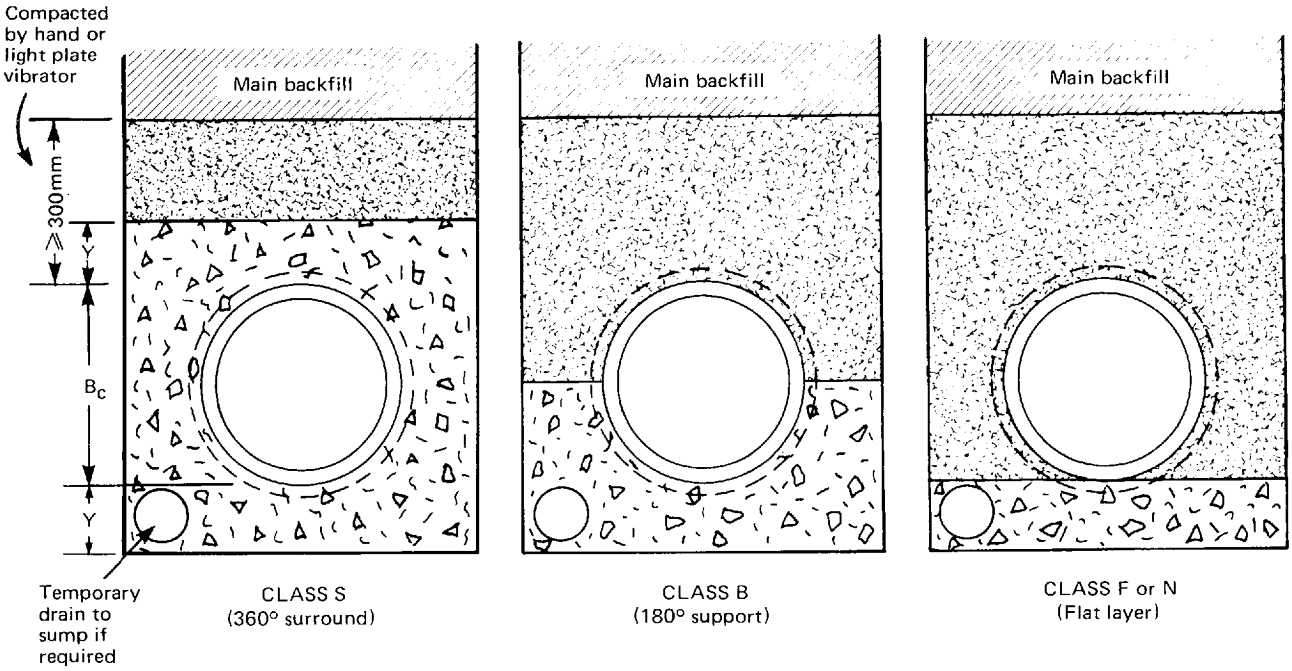
* As defined in Regulation D7 of the Building Regulations 1976.



CLASS S
(360° surround)

CLASS B
(180° support)

CLASS F or N
(Flat layer)

DIMENSION Y

(1) In rock or mixed soils containing rock bands, boulders, large flints or stones or irregular hard spots that result in an uneven trench bottom:

Y = 200mm minimum, but sufficient to provide at least 150mm under sockets

(2) In soils that permit an even trench bottom to be excavated:

Y = 100mm minimum, but sufficient to provide at least 50mm under sockets

▨ Fill selected to be free from large stones, building rubbish, tree roots, vegetable matter, and clay lumps greater than 75mm
Compacted by hand or light plate vibrator, especially at the sides

▦ Selected granular material, as per table below, compacted

NOMINAL MAXIMUM AGGREGATE SIZE (mm) : BS 882 grading					
Pipe bore (mm)	Aggregate	Bedding class			
		S	B	F	N*
100	Single Sized Graded	10 —		10 —	*
150	S.S. G	10 or 14 14 to 5		10 or 14	*
225	S.S. G	10, 14 or 20 14 to 5 or 20 to 5		10, 14 or 20	*
300	S.S. G	10, 14 or 20 14 to 5 or 20 to 5		10, 14 or 20	*

See text for use of alternative materials

* Construction similar to Class F but with bedding material to the following specification:
either "all-in" aggregate having a maximum particle size no larger than that indicated in Column 3
or "coarse", "medium" or "fine aggregate" to BS 882/1201

Fig. 3 Granular beddings

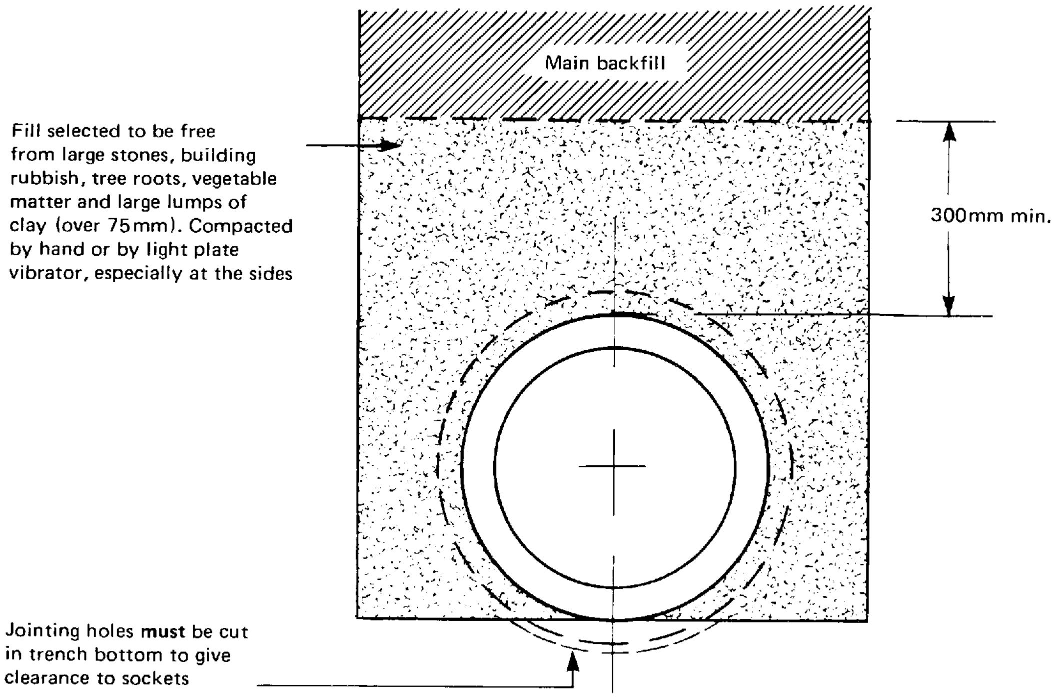


Fig. 4 Class 'D' Bedding Trimmed trench bottom

Type VII* Very soft silt, clay, sandy clay or silty clay which if squeezed in the fist exudes between the fingers. In soils which are only just acceptable and where the cover depth is small, there may be risk of disturbance of the pipeline by the passage of construction traffic. Care is therefore needed in the control of such traffic in these conditions.

Any soil that contains very large stones or flints is unsuitable because it would be difficult to trim accurately and the presence of stones immediately under the pipe could result in dangerous concentrations of load.

Particular care is needed during construction when the pipe length/diameter ratio exceeds 8, to avoid the possibility of uneven support along the pipe length, otherwise the use of shorter pipes or another type of bedding must be considered.

5 LIMITATIONS ON DEPTH OF COVER AND TRENCH WIDTH

5.1 DEPTH OF COVER

Tables 1 to 3 show the range of cover depths for which the different pipes in Section 3 are suitable when laid on the various beddings described in Section 4. The depths considered in the preparation of the tables extend from a minimum of 0.6 m to a maximum of 6 m. To avoid interference with other services CP 2005 recommends that sewers under roads should not have less than 1.2 m cover. However, to cater for the conditions where construction traffic can operate over the pipeline before the full cover depth is attained (see 2.4), depths to a minimum of 0.6 m are included in the tables.

5.2 TRENCH WIDTH

In order to avoid the need to restrict trench width it is now becoming customary with pipes up to 300 DN to design for a 'wide trench' loading except as may be dictated by other considerations. However, to provide against the situation where it is thought desirable to take advantage of any reduction in loading that would result from the employment of a 'narrow' trench, alternative permissible laying depths (shown in brackets) are given in the tables on the assumption that the effective width as defined in Figure 1, is restricted to that given at the head of the table.

6 TRENCH BACKFILL

Normally the material from the trench will be used for refilling, but if it is of a type difficult to compact and settlement of the surface must be minimised, as for example where a road is to be constructed over it, it may be desirable to import more suitable material. In any case a proper compaction technique is essential; material should be spread in regular layers not more than 300 mm thick and each layer thoroughly compacted before the next layer is placed. Heavy compactors should not be used until there is a minimum of 600 mm

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* As defined in Regulation D7 of the Building Regulations 1976.

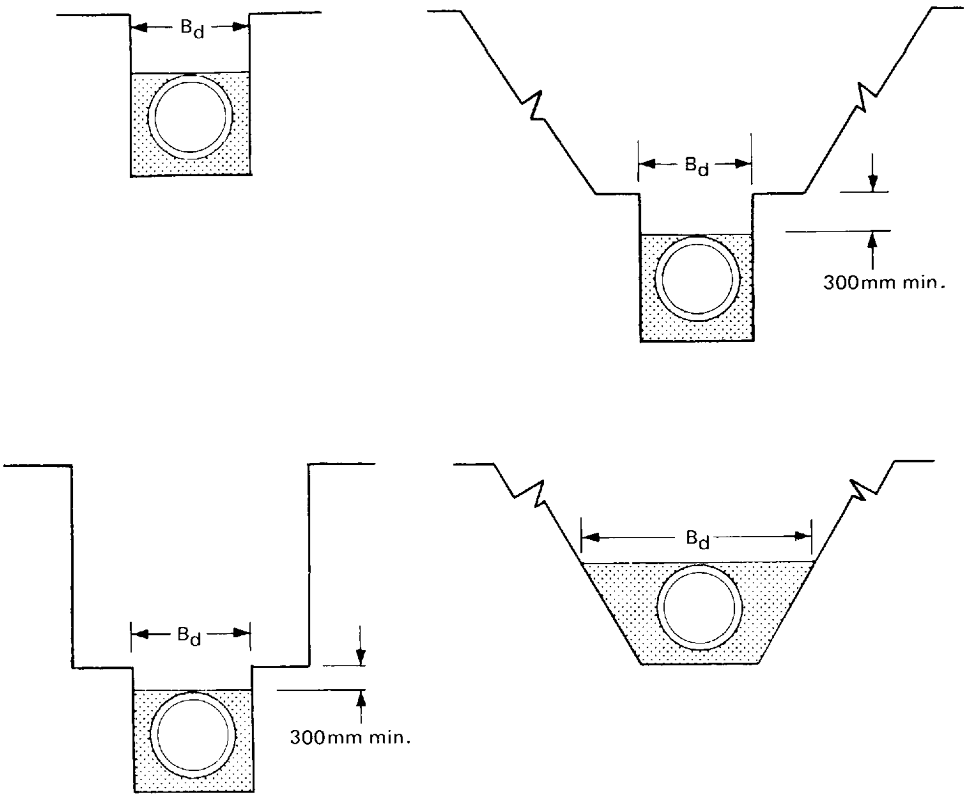

Fig. 1 Effective width (B_d) of trenches

of cover over the pipes. Trench sheeting should be removed as the work proceeds so that the spaces are properly filled.

7 TABLES OF MINIMUM AND MAXIMUM RECOMMENDED COVER DEPTHS

The tables cater for three categories of surcharge loading viz: Table 1 for pipes under 'main roads', ie main traffic routes and roads liable to be used for the temporary diversion of heavy traffic. The surcharge is taken to be 45 units of Type HB loading as in BS 5400: Part 2: 1978 and consists of eight wheels each of 112.5 kN inclusive of impact.

Table 2 for pipes under 'Light roads', ie all roads other than those covered by Table 1. The surcharge is taken as consisting of two wheel loads each of 105 kN inclusive of an impact factor of 1.5, spaced 0.9 m apart.

Table 3 for pipes under fields, gardens and lightly trafficked access tracks. The surcharge consists of two wheel loads each of 60 kN inclusive of an impact factor of 2.0. spaced 0.9 m apart.

7.1 EFFECT OF COVER DEPTH ON LOAD

The backfill load on a pipeline decreases progressively with decreasing cover depth, but the effect of traffic increases very sharply with decreasing depth. As a result, the total combined load has a minimum value at about 1.2 to 1.6 m and increases at both lesser and greater depths. Thus for a given supporting strength there is a minimum and a maximum recommended safe cover depth. Tables 1–3 give this range of depths for the standard pipes listed below when laid on various beddings (section 4).

7.2 TYPES OF PIPES

Clay—BS 65: 1981. Vitrified clay pipes, fittings and joints.

Concrete—BS 5911: Part 1: 1981. Precast concrete pipes and fittings for drainage and sewerage.

Asbestos-cement—BS 3656: 1981. Asbestos-cement pipes, joints and fittings for sewerage and drainage.

7.3 GENERAL NOTES RELATING TO TABLES 1–3

(i) The tables frequently show more than one combination of pipe strength and bedding class as suitable. Unless there are other over-riding considerations the choice will then depend on minimum overall cost. As a general guide combinations employing weaker beddings will usually prove cheaper than those employing stronger beddings.

(ii) The letters 'a' and 'b' in the tables indicate that the pipe on that bedding may be used at any depth within the range embraced by the tables, viz: 0.6 to 6.0 metres, subject to the considerations mentioned in 5.1. The alternative letters are used to draw further attention to the point made in note (i), ie combinations marked 'a' are likely to prove cheaper than those marked 'b'.

(iii) The letter 'x' in the tables indicates that the pipe on that bedding is not usable at any depth.

(iv) A blank in the tables indicates that no standard pipe of that size and class is available.

8 ACKNOWLEDGEMENTS

This report was prepared in the Ground Engineering Division of the Highways and Structures Department of the Transport and Road Research Laboratory. The material on which the report is based has been drawn from a number of sources (see list of references) to whom the author is greatly indebted, as well as from recent research carried out by TRRL.

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10 APPENDIX

Tests for suitability of soil material for use as granular beddings Classes S, B, F or N

Particle Size

The maximum particle size should not exceed that specified in Section 4.3 (Figure 3) according to pipe diameter. In cases of doubt this should be checked by a sieve test on a representative* sample weighing about 2.5 kg. Not more than 5 per cent by weight of the sample should be retained on the sieve size corresponding to the maximum particle size specified in Figure 3, and none should be retained on the next size larger sieve. Particles should be hard and stable, and not such as would readily crumble when wetted.

Ease of Compaction Test

Apparatus required: Open-ended cylinder 250 mm long and 145 to 160 mm internal diameter (eg 150 mm nominal internal dia pipe); metal rammer 40 mm dia and 1 kg in weight.

Obtain a representative* sample more than sufficient to fill the cylinder (about 10 kg). It is important that the moisture content of the sample should not differ materially from that of the main body of material at the time of its use in the trench.

Place the cylinder on a firm flat surface and gently pour the sample material into it, loosely and without tamping, strike off the top surface level with the top of the cylinder and remove all surplus material. Lift the cylinder up clear of its contents and place on a fresh area of flat surface. Place about one quarter of the material back in the cylinder and tamp vigorously until no further compaction can be obtained. Repeat with the second quarter, tamping as before, and so on for the third and fourth quarters, tamping the final surface as level as possible.

Measure down from the top of the cylinder to the surface of the compacted material, and express this as a fraction of the overall height, viz 250 mm.

Compaction (mm)	*Fraction*	*Suitability*
Not exceeding 37.5	Not exceeding 0.15	Material suitable for bedding Classes S, B and F
37.5 to 75	0.15 to 0.30	Material suitable for bedding Classes B or N but requires more care in compaction.
over 75	over 0.30	Material not suitable.

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* A representative sample is obtained by successively 'quartering' a much larger sample, say 50 kg or more, until a sample of about the right weight is obtained.

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