CHAPTER ELEVEN

Specification of Sewers and Drains

THIS chapter is primarily concerned with the drafting of specification clauses covering the provision, laying and jointing of sewers and drains in a variety of materials. The specification will also pick up associated operations such as excavation, timbering, backfill, etc., of sewer trenches, concrete protection to pipes and testing pipes. Where large-diameter sewers are to be laid in tunnel, the provision, jointing and grouting of shaft and tunnel segments will probably arise.

A sewer specification would not be complete unless it included clauses covering the construction of manholes, which could be of brick, in situ concrete or precast concrete tube construction. Various items of ancillary equipment must also be covered where applicable, such as benchings, channels, covers, boxsteps, step irons, ladders, safety bars and safety chains.

The chapter will conclude with a few miscellaneous items connected with sewerage schemes and sewage disposal works, such as media for filters, filter distributors and ventilating columns.

As with preceding works sections, a logical sequence of items is advisable and a useful approach follows.

(1) MATERIALS

Various types of pipe and other materials and components such as manhole covers, step irons, bricks, cement, aggregates, steel reinforcement, etc. The last three classes of material will not be covered in the clauses produced in this chapter as they have been covered in earlier chapters.

(2) Excavation

Typical matters to be covered here include trench excavation, trial holes, timbering, supports to crossings, keeping excavations clear of water, excess excavation, backfill and location of pipelines.

(3) Pipelaying

A list of matters commonly encountered includes loading and unloading pipes, laying pipes, building in pipes, jointing various types of pipe, cutting pipes, keeping pipes free from obstruction, stoppers, concrete protection, thrust blocks and testing pipes.

(4) Manholes

These can be subdivided into types and include various ancillary features such as channels, benching, ladders, safety chains and bars, etc. Special provision must be made for any out-of-the-ordinary types of manhole such as back-drop manholes, dual manholes and overflow manholes.

(5) Tunnel and Shaft Linings

Work under this head can normally be conveniently broken down into three main subdivisions: excavation work; provision of cast iron or precast concrete segments, etc.; and work in assembling, jointing, grouting, etc.

(6) Ancillary Work

Sewer outfalls, ventilating columns, storm overflows and small pumping chambers could come within this category. Many of the detailed specification requirements, such as those relating to excavation, concrete, shuttering, waterproofing, etc., will have already been covered elsewhere. Similarly, the majority of items in sewage works construction

have been detailed in earlier chapters under their appropriate works sections.

A selection of typical specification clauses covering the more usual sewerage and drainage items now follows.

TYPICAL SPECIFICATION CLAUSES	EXPLANATORY NOTES

MATERIALS

Glazed vitrified clay pipes

Glazed vitrified clay pipes shall be of British Standard quality complying with B.S. 65 and the necessary test certificates shall be supplied to the Engineer. Clay drain fittings shall comply with B.S. 539, Part 1.

This Standard covers two types of socket: (1) for use with manufacturers' special or flexible joints; (2) grooved or roughened for use with users' jointing materials. Clay pipe diameters range from 75 mm (3 in.) to 900 mm (36 in.).

Concrete pipes

Concrete and reinforced concrete pipes and fittings shall comply with B.S. 556 and shall be provided with an approved type of flexible joint. Straight pipes shall be centrifugally spun. Test certificates shall be supplied to the Engineer.

Normal effective lengths are 1, 1·25, 2 and 2·5 m (3, 4, 6 and 8 ft), and pipe diameters range from 150 mm (6 in.) to 1·25 m (48 in.). Standard tests include hydraulic proof tests, absorption and crushing proof tests.

Spun-iron pipes

Spun-iron pipes shall comply with the requirements of B.S. 1211 for class B pipes and shall have bolted gland joints of approved design. Test certificates shall be supplied to the Engineer.

Pipe-diameters range from 75 mm (3 in.) to 600 mm (24 in.) and the most commonly used lengths are 3·6 m (12 ft) and 5·5 m (18 ft). The tests are hydraulic, mechanical and for straightness.

Cast iron specials

Cast iron specials shall comply with the requirements of B.S. 78 for class B pipes and fittings, and shall have bolted

Class B pipes and fittings are tested to a pressure of 120 m (400 ft) head of water.

gland joints of approved design. Test certificates shall be supplied to the Engineer.

Bolted gland joints give some degree of flexibility, as distinct from caulked lead joints which are entirely rigid.

Pitch-fibre pipes

Pitch-fibre pipes and fittings shall be obtained from an approved manufacturer and shall comply with B.S. 2760. Test certificates shall be supplied to the Engineer.

This type of pipe is being used to an increasing extent for drainage work. Joints are formed of tapered spigots fitting tightly into couplings.

Asbestos cement pipes

Asbestos cement pipes shall comply with B.S. 3656, class 3. Test certificates shall be supplied to the Engineer.

These pipes are made in diameters ranging from 100 mm (4 in.) to 600 mm (24 in.) and in four lengths from 1 m (3 ft 3 in.) to 5 m (16 ft 4¾ in.).

Porous pipes

Porous concrete pipes shall comply with B.S. 1194.

These pipes are used for under-drainage and are made with rebated or O.G. joints in diameters ranging from 75 mm (3 in.) to 900 mm (36 in.).

Bricks

All bricks used in manholes shall be class B engineering bricks complying with B.S. 3921. In addition they shall be hard, sound, square, well burnt, uniform in texture, and regular in shape, with true square arrises and even in size. Care shall be taken in unloading, stacking and handling and no chipped or damaged bricks shall be used. All bricks shall be equal to samples submitted to and approved by the Engineer before any brickwork is commenced.

There are two classes of engineering bricks. Class A bricks have a minimum average compressive strength of 69 MN/m^2 (10,000 $lbf/in.^2$), while that for class B bricks is 48·3 MN/m^2 (7000 $lbf/in.^2$). It is advisable to use only the engineering type of brick in manholes owing to the humid and corrosive atmosphere prevailing.

Manhole covers

Cast iron manhole covers and frames shall comply with B.S. 497. Where subject to vehicular traffic they shall be grade A, heavy duty, double triangular type with a 550 mm (22 in.) clear opening and weighing 250 kg (5 cwt), as Table 1 of the Standard. Those not subject to vehicular traffic shall be grade B, medium duty, rectangular solid type and weighing 121 kg (2 cwt, 3 qr, 7 lb), as Table 5.

B.S. 497 covers a wide range of shapes, sizes and weights of manhole covers to suit many different sets of circumstances.

Step irons

Manhole step irons shall be of galvanised malleable cast iron complying with the requirements of B.S. 1247 for 'general purpose pattern' step irons, for building into brickwork or in situ concrete.

This British Standard covers three types of step iron: general purpose pattern; precast concrete manhole pattern; and round bar pattern. Minimum weights of step irons vary from 1·5 kg ($3\frac{1}{2}$ lb) to 2·5 kg ($5\frac{1}{4}$ lb) each.

EXCAVATION, ETC.

Trench and manhole excavation

All excavations shall be carried out to the dimensions, levels and gradients shown on the Drawings or as directed by the Engineer, in whatever material may be encountered. Extra payment will be made for excavation in rock as previously defined.

The top-soil shall be excavated separately and be kept separate from the sub-soil, for subsequent replacement on

It is essential that all pipe trenches should be excavated to the required lines and levels. The width of the trenches is usually determined by a number of factors, such as pipe size, depth of trench, type of soil and plant available.

A suitable definition of

the ground surface. Paved surfaces disturbed in the course of excavation shall be set aside for future use as directed by the Engineer.

Excavation shall not, in the first instance, proceed closer than 75 mm (3 in.) to formation level. The remaining 75 mm (3 in.) shall be excavated by hand on the same day as the laying of the pipes or concrete bed. The width of pipe trenches shall be adequate to permit the satisfactory laying and jointing of pipes.

rock is given in the excavation specification clause in Chapter IV. Where unstable conditions are encountered at formation level, it is good practice to excavate 75 mm (3 in.) or 100 mm (4 in.) below formation level and fill with concrete.

Trial holes

The Contractor shall excavate all necessary trial holes in advance of pipelaying work and shall backfill them and reinstate and maintain the surfaces. Where prior approval of the Engineer has been obtained to the excavation of trial holes, the Contractor shall receive payment for this work. The Contractor shall, however, at his own expense, take all other reasonable action to determine the position of all underground services likely to affect the pipelaying work.

The excavation of trial holes approved by the Engineer will normally rank for separate payment to the Contractor. Nevertheless, the Contractor can be reasonably expected to obtain all possible information from statutory undertakers about their services with a view to avoiding the need for trial holes as far as possible.

Timbering to excavations

The Contractor shall, at his own expense, provide and fix adequate timbering to support the sides of excavations, and it shall be maintained until the constructional work is sufficiently far advanced to permit its removal. The removal of timbering shall be performed only under the direct supervision of a competent foreman. The Contractor shall be held entirely responsible for any damage or injury resulting from the

The Contractor must provide sufficient timbering to excavations to ensure the safety of the workmen and the permanent works. The cost of timbering is, as a general rule, to be covered in the excavation rates, and would not normally come within the category of 'special items of temporary works'.

inadequacy or premature removal of timbering. Where timbering is left in position on the direction of the Engineer for the permanent support of services or structural work, the Contractor shall be entitled to payment of the additional cost involved.

Supports for existing pipes, etc.

The Contractor shall, at his own expense, adequately timber, shore up, sling or support all pipes or other services in the vicinity of the new pipelines, and shall ensure their continuous effective operation.

Pipes and other services may cross over or under the new pipelines and will then need temporary support to prevent undue strain and possible damage.

Excavations to be kept free of water

The Contractor shall, at his own expense, keep all excavations free from water from any cause by pumping, draining or other means to the satisfaction of the Engineer and for such period as he may require. Any sumps and wells provided for this purpose shall be sited away from the permanent works and shall be subsequently filled with concrete, class D.

The water may arise from a number of sources – watercourses, subsoil water, land springs, existing drains and sewers, etc. The method adopted by the Contractor for the removal of the water will vary with the circumstances.

Excess excavation

Any excess excavation shall be filled with concrete, class D, at the Contractor's expense.

Concrete class D would probably be a 1:10 mix, although some engineers specify 1:3:6.

Backfilling excavations

Excavations for pipe trenches and manholes shall be backfilled in layers not more than 225 mm (9 in.) deep with well compacted and suitable material,

Particular care is needed in the backfilling of pipe trenches, to avoid any possibility of damage being caused

with particular care being taken at the sides of pipes. The backfilling material used at the sides of pipes and for a height of 450 mm (18 in.) above them shall be selected material free from large stones and consolidated with narrow wooden rammers. Where mechanical rammers are used to consolidate backfilled material in pipe trenches, the pipes shall be protected by not less than 1 m (3 ft) of hand rammed material. No backfilling shall proceed until the line of sewer has been approved by the Engineer.

to the pipes. The normal precautions include the use of selected material around the pipes and hand ramming in the lower part of the trench.

Location of pipelines

The finally agreed routes and levels of pipelines and the number, depths and locations of manholes may not necessarily coincide precisely with the information given on the Drawings, but will be determined by the Engineer or his representative in the light of information resulting from exploratory excavations or obtained from other sources. The contractor's rates for the permanent work shall be deemed to include for any delay or extra cost which the Contractor may incur as a result of deviations from the planned routes, depths and locations.

Although the Engineer will make every attempt to determine accurately the exact lines and levels of sewers during the pre-contract period, it may, nevertheless subsequently be necessary to make adjustments as further and more positive information concerning the position of other services, etc., comes to light.

PIPELAYING

Loading and unloading pipes

Pipes and specials of all kinds shall be handled with approved lifting tackle when loading or unloading. The Contractor shall not roll pipes down timbers

The Contractor must take care in handling all pipes and specials to prevent damage to them. Pitch-fibre pipes

or inclined ramps without the Engineer's special consent.

Pitch-fibre pipes shall be handled strictly in accordance with the manufacturer's recommendations. Pitch-fibre pipes shall be stacked parallel to one another on level ground, without couplings, with stack heights not exceeding 2 m (6 ft).

need special attention and it is advisable to draw the Contractor's attention to the manufacturer's recommendations.

Laying pipes

Each pipe before laying shall be brushed out and examined, and each cast iron or spun iron pipe shall be tested for soundness by striking with a hammer while the pipe is suspended clear of the ground. When laying pipes, adequate precautions shall be taken to ensure that no bricks, soil or other materials enter the pipes already laid, and a close-fitting stopper shall be placed in the end of the last pipe when work is interrupted.

Pipes shall be laid with the sockets leading uphill and shall rest on even and solid foundations for the full length of the barrel. Socket holes shall be formed in the trench bottom, sufficiently deep to allow the pipe jointer adequate space to work round the pipes, and as short as is practicable to accommodate the socket and permit the joint to be made. In rock or stony ground the pipes shall be evenly laid on a bed of sand, not less than 50 mm (2 in.) thick.

Where pipes are to be laid on a concrete bed, the concrete under and around the pipes shall be laid in a single operation. Precast concrete blocks, one at the back of each socket, or suitably

It is imperative that all sewer pipes should be laid true to line and level, to prevent any risk of blockages when in use. Precautions must be taken to ensure that the barrel of each pipe bears evenly upon a solid foundation, whether of soil or concrete.

Sight rails should be not less than 150 mm (6 in.) deep with their top edges planed true and straight. The centre-line of the pipe should be shown by a vertical line on both front and back faces, and for greater clarity the rail should be painted in contrasting colours.

The boning rods should be accurately made to the various lengths in even feet, with a shoe of sufficient projection to rest on the invert of the last laid pipe. On large diameter sewers laid at flat gradients, the levels of the work should be frequently checked by

wedged bricks for the smaller diameter pipes, shall be used to support the pipes before the concrete is laid. After each block or brick has been properly set and boned in to the correct level, and the pipes laid on them and properly centred and socketed, two hardwood wedges shall be inserted transversely between the body of the pipe and the block, and they shall then be driven together until the pipe is brought to the exact level required.

All pipes shall be of the dimensions, materials and classes shown on the Drawings or as directed by the Engineer and shall be accurately laid to the required lines and gradients. All pipes shall be laid in dead straight lines in both horizontal and vertical planes between manholes. Proper sight rails and boning rods shall be used to ensure that each pipe is laid to the correct levels, and sight rails shall be provided at each change of gradient and not more than 45 m (50 yds) apart.

instrument. See Civil Engineering Code of Practice, CP 5: Drainage (Sewerage).

Building-in of pipes

When pipes are built into brick walls of manholes, semi-circular single ring brick-on-edge arches shall be turned over them.

This provision aims at relieving the pipe of the weight of wall above. An alternative is to use concrete lintels.

Jointing of pipes generally

Experienced pipe jointers only shall be permitted to carry out the work of pipe jointing. Special instructions of the pipe manufacturer, such as with flexibly jointed pipes, shall be followed closely. Jointing of pipes prior to lowering them into a trench will not be permitted

Jointing of pipes is a skilled operation and needs to be performed by experienced workmen. Flexibly jointed pipes are being used to an increasing extent and are particularly well suited

except under special circumstances with the approval of the Engineer.

for use in bad ground conditions, in areas subject to mining subsidence, sea outfalls, etc.

Jointing of clayware and concrete pipes

Pipes to be jointed with yarn and cement mortar shall each be placed well home into the socket of the previously laid pipe. Each shall be jointed with one complete lap of best plain hempen spun yarn dipped in liquid cement mortar and tightly driven home by caulking to occupy not more than one-quarter of the total depth of the socket. The remaining space in the socket shall then be filled with cement mortar (1:2), which shall be trowelled on the face to form a splayed fillet completely covering the exposed end of each socket.

The mortar for jointing shall be of the consistency of putty and shall be well caulked into the socket of the pipe with a wooden caulking tool. The joints shall be clean and smooth on the inside face and the interior surfaces of all pipes shall be kept perfectly clear of all jointing material and other extraneous matter. Joints shall be left undisturbed until set and ready for testing.

Many clayware and concrete pipe sewers are still made with yarn and mortar joints, despite their numerous disadvantages. The joints form the weakest link in the pipeline and thus need to be specified in considerable detail with the object of securing sound, watertight joints. Some engineers specify the angle which the cement fillet shall subtend from the face of the socket (30° or 45°) but the writer prefers the method used in the accompanying clause. A mortar mix of 1:2 produces adequate strength and there is less shrinkage on setting than with a richer mix.

Jointing of iron pipes

Cast iron and spun iron pipes shall be jointed with standard plain white hempen spun yarn and good quality soft blue pig lead. At least one complete lap of yarn shall be caulked into the back of the socket to prevent the escape of molten lead and shall not project inside the pipe. The lead shall be run at a single

Standard spigot and socket iron pipes are normally jointed with yarn and molten lead in the manner described in the accompanying specification clauses. Caulking lead or lead-sheathed yarn can be used in place of spun yarn.

pouring to a minimum depth complying with the following schedule.

Diameter of pipe mm (in.)	*Minimum depth of lead per joint mm (in.)*
Not exceeding 100 (4)	45 ($1\frac{3}{4}$)
125 to 150 (5 to 6)	50 (2)
175 to 200 (7 to 8)	55 ($2\frac{1}{4}$)
225 to 1070 (9 to 42)	60 ($2\frac{1}{2}$)
exceeding 1070 (42)	65 ($2\frac{3}{4}$)

The pipe surfaces to be jointed shall be thoroughly cleaned and dried before the lead is poured. The lead after pouring shall project 3 mm ($\frac{1}{8}$ in.) from the socket to allow for caulking. As soon as the lead is cool it shall be properly caulked with caulking irons and 1·75 kg (4 lb) hammers, finishing with a neat and even surface flush with the face of the socket.

Flanged joints shall be properly made with rubber joint rings complying with B.S. 2494 and mild steel bolts and nuts with the bolts projecting two threads beyond the nuts.

Patent flexible joints shall be made strictly in accordance with the manufacturer's directions.

Fibrous lead may be used as a substitute for run lead, probably in the form of a double collar fibrous-lead joint with spun yarn between the two lead collars, occupying not more than one-third of the total depth of the socket. Fibrous lead is particularly suitable for use under wet conditions and in headings where the use of molten lead might prove dangerous to the workmen.

Jointing of asbestos-cement pipes

Asbestos-cement pipes shall be jointed with approved asbestos-cement screw collars, and specials with suitable detachable joints. All joints shall be made strictly in accordance with the manufacturer's directions. Cut ends of asbestos-cement pipes shall be turned to the correct external diameter for a length of at least 75 mm (3 in.).

Asbestos-cement pipes are used occasionally in drainage work. They have the advantage of easily-formed joints.

Jointing of pitch-fibre pipes

Pitch-fibre pipes shall be laid and jointed in accordance with Appendix C of B.S. 2760: Pitch-impregnated Fibre Drain and Sewer Pipes. Particular care shall be taken to ensure that all spigots and sockets are absolutely clean and free from grit immediately prior to jointing.

The ends of cut lengths of pitch-fibre pipe shall be finished truly square and spigots shall be properly turned with a special tool supplied by the manufacturer.

Pitch-fibre pipes are being used to an increasing extent particularly on rural drainage schemes. They have many advantages, including long lengths and easily-formed joints, and are particularly well suited for use in bad ground conditions.

Cutting pipes

Pipes shall be cut as necessary to accommodate valves, bends, junctions, etc., and for the proper connection of pipelines. All cuts shall be performed with suitable cutting tools and apparatus.

The main purpose of this clause is to prevent the use of hammers and chisels for cutting pipes.

Junction pipes

Junction pipes shall be inserted in the positions shown on the Drawings or where directed by the Engineer. Any branches which are not immediately connected up shall be closed with joinder caps or clayware discs, set in and filled up to the ends of the sockets with puddled clay and a cement fillet. The position of each junction shall be accurately recorded on a layout plan and in a 'junction book'.

Junction pipes will be needed to pick up present and future connections. The open ends need to be properly sealed and their locations duly recorded.

Concrete protection to pipes

All concrete beds, haunchings and surrounds to pipes shall be of class D

It is often specified that pipes in heading, with 6 m

and extend for 150 mm (6 in.) from the outside surface of the pipe. Concrete beds shall be rectangular in cross section and the concrete shall be carefully packed under and around the pipes, taking care not to displace the pipes in any way. In haunchings the concrete shall be carried up to the horizontal diameter of the pipe and then splayed off tangentially to the top of the pipe. Surrounds shall be carried over the pipes to give 150 mm (6 in.) cover to the barrels at all points.

Concrete beds, haunchings and surrounds to pipes shall be discontinued at flexible joints by the insertion of sheets of approved compressible joint filler.

(20 ft) or more of cover or with less than 1·25 m (4 ft) of cover or 1 m (3 ft) elsewhere shall be surrounded with concrete. Pipes of 450 mm (18 in.) diameter and over (1·25–6 m (4–20 ft) cover) and smaller pipes (4·2–6 m (14–20 ft) cover) are often bedded and haunched in concrete. A common mix of concrete is 1:3:6.

It is now becoming the practice to design the pipes to take the loads rather than to surround them with concrete.

Thrust blocks

All pumping mains and other pipelines that are to be tested at high pressure shall be provided with concrete thrust blocks at all bends, junctions, blank ends, etc., all to the approval of the Engineer. End shuttering may be used but the other faces of thrust blocks shall bear directly against undisturbed ground, and flexible joints must have freedom of movement.

A common mix of concrete for thrust blocks is 1:3:6. It is sometimes specified that the Contractor shall be entirely responsible for any consequences of lack or inadequacy of thrust blocks.

Testing of pipelines generally

Pipelines shall be tested before any concrete haunch or surround is laid or backfilling commenced, except where the latter is necessary for access purposes or for testing at high pressure. The Contractor shall at his own expense uncover any such pipes to remedy leaks or other faults.

As far as possible all pipe joints should be exposed at the time of testing, which must be carried out under suitable conditions and in the presence of the Engineer's representative.

It is good policy to add

All tests shall be carried out in daylight in the presence of the Engineer's representative, using water which is coloured substantially with fluoresceine. Pipelines shall be tested in lengths between manholes or in shorter lengths with the Engineer's approval.

The Contractor shall supply all necessary testing apparatus and water, and shall fill and empty the pipes and dispose of the surplus water. Any pipes showing leaks, sweating or other signs of porosity, shall be condemned and shall be replaced and re-tested at the Contractor's expense.

fluoresceine to the testing water as the distinctive colour will immediately draw attention to any leaks. Special items are sometimes included in bills of quantities to cover the cost of testing work, but in other cases the cost is to be covered by the pipelaying rates.

Testing of non-pressure pipelines

All gravitational pipelines shall be tested with water to a head of not less than 1·5 m (5 ft), measured from the crown of the highest pipe under test. At no point shall the pressure exceed the safe pressure specified for the pipes by the manufacturer.

After allowing a short period for absorption, the vertical pipe at the head of the length under test shall be topped up and the water level observed for not less than 10 minutes. Should the water level drop by more than 25 mm (1 in.), the cause shall be sought and the defect remedied.

After the test, the water shall be released from the stopper while a watch is kept on the vertical pipe, to check that the pipeline and the vertical pipe are unobstructed. No testing shall commence within 48 hours of the making of cement joints.

Where it is difficult to apply a water test, the Contractor may be permitted

The majority of sewers and drains are tested by a water test. A quarter bend is jointed temporarily to the socket of the last pipe laid and vertical pipes or tubes are fitted to the bend to give the desired head. The Code of Practice on Sewerage recommends a minimum head of 600 mm (2 ft) whereas the Code of Practice on Building Drainage advocates a minimum head of 1·5 m (5 ft).

Some engineers advocate the fitting of a vertical tube of not less than half the diameter of the pipes under test. Another alternative specification requirement is that the loss of water under test shall not exceed 1/1000 of the total volume of water in the pipeline.

to apply an air test to gravitational pipelines exceeding 375 mm (15 in.) in diameter. The air pressure measured in a manometer tube shall be raised by a hand pump to 100 mm (4 in.) head of water. Should the fall of pressure exceed 25 mm (1 in.) of water in the 5 minutes following the cessation of pumping, the cause shall be sought and the defect remedied.

Testing of pressure pipelines

All pressure pipelines shall be tested by filling with water coloured with fluoresceine and raising the pressure by injecting further water through a manually operated forcepump, fitted with an accurate pressure gauge, until the following pressures are obtained:

Class D pipes: 1·8 MN/m² (260 lbf/in.²)
Class C pipes: 1·4 MN/m² (200 lbf/in.²)
Class B pipes: 0·9 MN/m² (130 lbf/in.²)

The pump shall then be disconnected from the pipeline and the required pressure shall be maintained for 30 minutes.

Pumping mains and pipes in syphons will normally be subjected to this type of test. The pressure must vary with the class of pipe used in the pipeline. The normal period of test is 30 minutes.

Alternatively, the pressures could be expressed in N/mm².

Testing of pipelines for obstructions

Pipelines of 525 mm (21 in.) diameter or less shall be tested to ensure that they are free from obstruction after having successfully withstood a water test. A loose spherical or cylindrical plug of the diameter shown in the schedule shall be passed through the whole of the pipeline. Any obstruction encountered shall be removed or any unevenness of invert shall be made good to the satisfaction of the Engineer.

Tests for straightness and obstruction can be carried out in one of two ways: (1) by rolling a ball or passing a plug through the pipeline, (2) by placing a mirror at one end of the pipeline and a lamp at the other. If the pipeline is straight, the full circle of light can be observed. The mirror will also show any

TYPICAL SPECIFICATION CLAUSES

Pipe diameter mm (in.)	*Plug diameter mm (in.)*
100 (4)	95 ($3\frac{3}{4}$)
150 (6)	145 ($5\frac{3}{4}$)
225 (9)	215 ($8\frac{5}{8}$)
250 (10)	238 ($9\frac{1}{2}$)
300 (12)	288 ($11\frac{1}{2}$)
375 (15)	363 ($14\frac{1}{2}$)
450 (18)	438 ($17\frac{1}{2}$)
525 (21)	513 ($20\frac{1}{2}$)

After the test has been successfully performed, a close-fitting stopper shall be placed at the head of the pipeline and shall be kept there until the manhole has been constructed.

EXPLANATORY NOTES

obstructions in the pipes.

The first method is best suited for testing sewers.

MANHOLES

Brick manholes

Brick manholes shall be constructed in accordance with the Drawings and in the positions shown on the layout plan or where directed by the Engineer. Concrete bases shall be of concrete class B, laid on waterproof paper, and of the thickness shown on the Drawings.

The chamber walls shall be constructed in 225 mm (9 in.) brickwork in class B engineering bricks laid in English bond in cement mortar (1:3), with the internal face finished fair and flush pointed.

No bats or broken bricks will be permitted except as closers, and all bricks shall be wetted before use and be laid with the frogs upwards. All bed and vertical joints of brickwork are to be filled solid with mortar and no vertical joint may be flushed up from the top.

Brick manholes are best constructed of engineering bricks finished with a fair face internally. The minimum size of a brick manhole chamber should be 1·25 m × 790 mm (4 ft $1\frac{1}{2}$ in. × 2 ft $7\frac{1}{2}$ in.) and an access shaft should be not less than 790 mm × 675 mm (2 ft $7\frac{1}{2}$ in. × 2 ft 3 in.).

225 mm (9 in.) walls are usually adequate for manholes up to about 3 m (10 ft) deep. For deeper and larger manholes, the walls should be thickened up as the depth increases to take account of the ground and/or water pressure. Channels, benchings, step irons, covers, etc.,

No joints shall exceed 10 mm ($\frac{3}{8}$ in.) in thickness.

Brick courses shall be level and straight with perpends kept in vertical alignment. All brickwork shall be cleaned off after completion and left free from deposits of mortar, etc.

Concrete cover slabs shall be of reinforced concrete, class B, of the dimensions shown on the Drawings.

are dealt with later in the chapter.

Precast concrete manholes

Precast concrete manholes shall be constructed on a base of concrete, class B, 150 mm (6 in.) thick laid on waterproof paper, and a base wall of similar class concrete of a thickness equal to the thickness of the chamber rings plus 150 mm (6 in.).

The chamber rings shall be 1·1 m (42 in.) in diameter, jointed in cement mortar (1:2), flush pointed internally and surrounded externally with concrete, class B, to a minimum thickness of 150 mm (6 in.).

Taper rings reducing from 1·1 m (42 in.) to 675 mm (27 in.) diameter shall be of the straight back type and shall be placed so that the bottom of the taper ring is not less than 1·5 m (5 ft) above the top of the manhole benching. Where the chamber is less than 2·75 m (9 ft) deep the taper ting shall be feplaced by a precast reinforced concrete slab supplied by the ring manufacturer.

Shaft rings shall be of 675 mm (27 in.) diameter and making-up pieces shall be provided where necessary to bring the precast concrete cover slab to the required level. A brick necking of up to three courses of 225 mm (9 in.) brick-

Precast concrete manholes can be quickly constructed by unskilled labour and are particularly advantageous in bad ground conditions. The chamber rings are made from 920 mm (36 in.) to 2 m (72 in.) diameter and shaft rings of 675 mm (27 in.) diameter are available in lengths of 150 mm (6 in.) to 1·25 m (4 ft) in multiples of 150 mm (6 in.), all with step irons cast in at the factory.

An alternative to in situ concrete base walls is to use precast concrete invert blocks specially made to suit each individual manhole.

Manholes are occasionally constructed in in situ concrete, where there is considerable repetition work and shuttering can be standardised and re-used. The cover slab should be constructed monolithic with the walls and care must be taken to make the concrete watertight.

work in engineering bricks in cement mortar (1:3) shall be constructed to bring the manhole cover to the correct level.

Benchings and channels

Main channels shall be formed of glazed vitrified clay half-round channels jointed in cement mortar (1:2) to easy curves and true levels. Branch channels shall be curved so as to discharge into the main channel at an angle of not more than 45°. Branch pipes shall be arranged to enter the manhole with their soffits level with the soffit of the main sewer.

Benchings shall be carried up vertically from the channels to the crown level of the largest pipe and then splayed off at a slope of 1 in 12, with the edges rounded to a radius of 20 mm ($\frac{3}{4}$ in.). Benchings shall be constructed of concrete, class B, finished off with a rendering coat of fine granolithic concrete (1:$2\frac{1}{2}$), 25 mm (1 in.) thick, trowelled smooth.

There are two methods in use for the construction of channels: (1) half-round clayware channels, as described; (2) fine concrete rendering in granolithic as described for the benching.

The slope of 1 in 12 to the top of the benching permits workmen to stand on the benching for inspection, rodding and repair work, and also enables deposited solid matter to fall back into the sewer.

Step irons

Step irons as previously specified shall be built into brick manhole walls as the work proceeds, at a spacing of 300 mm (12 in.) centre to centre vertically and 300 mm (12 in.) apart horizontally, in staggered formation.

Another way of describing the positioning of the step irons is 'built into the brickwork every fourth course and staggered 150 mm (6 in.) each side of the centre-line of the shaft walls.'

Boxsteps

Boxsteps shall be approved galvanised cast iron boxsteps, 225 mm ×

These are needed on large diameter sewers to enable

150 mm × 160 mm (9 in. × 6 in. × 6½ in.), each weighing 9 kg (20 lb) and built into the concrete benching in the positions shown on the Drawings.

workmen to reach the invert from the top of the benching.

Ladders

Ladders shall be provided to manholes exceeding 4·5 m (15 ft) deep, made of galvanised wrought iron with 65 mm × 25 mm (2½ in. × 1 in.) strings, 300 mm (12 in.) apart in the clear, drilled and fitted with 22 mm (⅞ in.) diameter rungs at 250 mm (10 in.) centres, every fifth rung to have a shoulder formed on the ends. The ends of all rungs shall be neatly riveted over.

The feet of the strings shall be turned outwards for a length of 50 mm (2 in.) and recessed into the concrete benching. At the top of each ladder the strings shall be bent to a radius of 150 mm (6 in.), with a straight length of 225 mm (9 in.) to penetrate the shaft wall, and turned outwards at the back of the wall. Wrought iron stays 65 mm (2½ in.) × 15 mm (½ in.) × 425 mm (17 in.) long shall be set into the manhole walls at intervals not exceeding 1·5 m (5 ft) and fixed to the ladder strings with 20 mm (¾ in.) mild steel bolts.

For manholes exceeding 4·5 m (15 ft) in depth, the Code of Practice on Sewerage recommends the use of galvanised wrought iron ladders in place of step irons. Strings or stringers should be not less than 60 mm × 10 mm (2½ in. × ½ in.) and rungs not less than 20 mm (¾ in.) in diameter. Ladders should be not less than 300 mm (12 in.) between strings with rungs at 250 mm (10 in.) centres.

Details of the method of fixing the ladders must be given.

Where an access shaft exceeds 7·5 m (25 ft) deep, enlarged rest chambers should be provided at 6 m (20 ft) intervals, each with a landing platform incorporating a hinged trap-door under the ladder.

Safety chains

Safety chains for use in manholes shall be galvanised wrought iron close-link, 10 mm (⅜ in.) thick, complying with B.S. 781. The chains shall each have one end fixed to a ring bolt and the other end shall be provided with a suitable hook for securing to a separate 225 mm (9 in.) ring bolt supplied ragged for building into brickwork.

All manholes on sewers of 1 m (3 ft) diameter and over should be provided with safety chains for placing across the mouth of the sewer on the downstream side when men are at work.

Safety bars

Safety bars shall be of galvanised pipe handrail of 40 mm (1½ in.) nominal bore with 225 mm (9 in.) ragged ends for building into brickwork.

Safety bars should be provided at the edges of all benchings, platforms, etc., from which a man might possibly fall into the sewer.

Manhole covers

Manhole covers and frames, as previously specified, shall be securely bedded in cement mortar (1:2). The top surface of the cover and frame shall be flush with the surface of any road, footpath or grass verge in which it is situated, or shall be 75 mm (3 in.) to 150 mm (6 in.) above adjoining ground level in other locations.

Manhole covers need to finish flush with paved surfaces and grassed areas, but in other cases it is advisable to finish several inches above the adjoining ground level for ease of location.

Tunnel and Shaft Linings

(Taking cast iron segments to shafts and precast concrete segments to tunnels).

Shaft segments

Shaft rings shall be of cast iron of 7 m (23 ft 2½ in.) internal diameter, with each ring 450 mm (1 ft 6 in.) long and consisting of ten ordinary plates, two top plates and one key. The approximate weight of each ring is 4400 kg (4·47 tons). Each plate shall be provided with a 30 mm (1¼ in.) diameter gas plug.

The cast iron rings are made up of a number of segments with bolted and caulked joints between them. Grout holes and plugs are provided in each segment or plate for grouting externally.

Tunnel segments

Tunnel rings shall be of precast reinforced concrete of 4·4 m (14 ft 6 in.) internal diameter, with each ring 600 mm (2 ft) long and consisting of seven ordinary plates, two top plates and one key. Each plate shall be provided with a

Precast concrete rings are of similar construction. See Chapter IV for excavation for tunnel work, tunnel driving and use of compressed air plant and equipment.

50 mm (2 in.) diameter grouting hole and plug.

Bolting cast iron segments

The Contractor shall provide grummets of approved design under the steel washers to heads and nuts of bolts, to prevent leakage occurring around the bolts. The tightening of bolts shall be carefully performed to ensure that the grummets are forced well home into the bevel of the bolt-holes and that the washers have an even bearing. Where the rings are erected under compressed air, the compressed air equipment shall be retained in working order until the Engineer is satisfied that the cast iron lining is watertight.

As soon as possible after assembly, the segments are bolted together with mild steel bolts, washers and grummets, to assist in securing a watertight joint.

Caulking longitudinal joints of cast iron segments

Caulking of longitudinal joints shall be carried out as soon as practicable after the cast iron lining is erected. Prior to caulking, the recesses shall be thoroughly cleaned by air jets, water jets, scraping or by a combination of these. Metallic lead shall be used for caulking, of the same width as the width of the recess. Where leakage occurs after caulking, the lead shall be removed and renewed. The remaining parts of the caulking recesses shall be tightly filled and pointed with cement mortar (1:3).

All caulking recesses need to be well cleaned before any lead is applied to the joints. After the strips of lead have been caulked into the joints, it is usual to fill the remaining space in the jointing recesses with cement mortar.

Caulking circumferential joints of cast iron segments

Preliminary jointing shall be carried out with tarred yarn during erection of

The process is similar to that specified for the longi-

the rings. As soon as practicable after erection, the spun yarn packing shall be removed, the joints shall be cleaned as previously described, and a continuous caulking of metallic lead applied behind the bolts, with lead block joints connecting the circumferential and longitudinal joints. The recesses shall be finished off with cement mortar (1:3) after the lead caulking has been checked for watertightness. The Contractor's prices for caulking circumferential joints shall include for taking out and replacing bolts, providing, cutting out and removing temporary tarred yarn packings, and cleaning out, caulking and pointing the joints.

tudinal joints, except that temporary tarred yarn packings are placed during erection, to be removed subsequently, prior to cleaning out and caulking the joints. It is also necessary to provide a sound connection between the circumferential and longitudinal joints with lead blocks.

When the work is carried out in compressed air, it is usual to caulk the joints temporarily with neat cement prior to grouting.

Grouting outside cast iron lining

The space between the shaft lining and the surrounding ground shall be filled completely with cement grout (1:2), mixed with sufficient water to permit it to be forced by compressed air through holes in the castings. The grouting shall be carried out as soon as practicable after the lining is erected and the joints caulked, and the holes shall be carefully plugged after grouting.

The void outside the tunnel or shaft lining is usually filled with cement grout (1 part cement to 2 parts sand) forced through the grout holes (one to each segment) under pressure.

Jointing precast concrete segments

The segments of precast concrete rings shall be bolted together with mild steel bolts, domed steel washers and approved grummets. In addition, creosoted deal or approved filling compound of 3 mm ($\frac{1}{8}$ in.) compressed thickness shall be placed in the circumferential joints, and approved bitumen filling in the longitudinal joints.

The segments of precast concrete rings are bolted together in a similar manner to cast iron segments, but strips of filling material are also inserted in the joints. The caulking grooves are filled completely with cement mortar.

The caulking groove between the precast concrete segments shall be thoroughly cleaned, wetted and tightly filled with stiff cement mortar (1:3). The finished work shall be watertight on completion and any unsatisfactory caulking or grummetting shall be cut out and replaced at the Contractor's expense.

Grouting outside precast concrete lining

Cement grout, as previously specified, shall be injected under pressure through the holes in the linings, so as to fill completely all the voids between the tunnel lining and the surrounding ground, and the holes shall be carefully plugged after grouting. Grouting shall commence at the invert and proceed upwards, allowing air and moisture to escape through the upper grout holes.

The tunnel linings will be grouted up externally to eliminate any voids outside the linings. Grouting should proceed from the bottom upwards.

Concrete lining to shaft and tunnel rings

A concrete lining of the thickness shown on the Drawings shall be applied to the inner face of shaft and tunnel rings, and finished to produce a dense, hard and smooth surface. The concrete shall consist of one part of sulphate-resisting cement to not more than four parts of total dry aggregate by weight, with a maximum aggregate size of 10 mm ($\frac{3}{8}$ in.) and a water/cement ratio not exceeding 0·50. The concrete shall have a nominal strength of 35 MN/m² (5000 lbf/in.²) and a minimum batch cube strength (6 cubes) in accordance with B.S. 1881 of 33 MN/m² (4750 lbf/in.²) at 28 days. The compacting fac-

With sewers, culverts and circulating water ducts, it is important that a sound, dense, non-corrosive and smooth interior surface is obtained to the tunnel lining. For this reason it is necessary to specify good quality concrete in every way suited to this purpose.

The reader is referred to the Code of Practice on Sewerage for details of brick-lined concrete sewers.

tor shall not exceed 0·87 and the slump shall not exceed 75 mm (3 in.).

The concrete shall be adequately mechanically vibrated between steel shuttering of approved design. Fabric reinforcement of type No. 130 to B.S. 1221 shall be provided where shown on the Drawings.

Ancillary Work

Ventilating columns

Ventilating columns shall be of reinforced centrifugally spun hollow concrete, 9 m (30 ft) high overall, 85 mm (3½ in.) diameter nominal bore, to stand 7·5 m (25 ft) above the ground, complete with a 150 mm (6 in.) branch connection, 200 mm × 150 mm (8 in. × 6 in.) galvanised inspection door and frame and galvanised wire balloon.

Alternative materials are asbestos cement and lap-welded steel. The latter is usually coated internally with Dr Angus Smith's solution and painted externally with two coats of bitumastic paint.

Percolating filter distributors

Rotary distributors for percolating filters shall be of 15 m (50 ft) diameter from an approved manufacturer, with four pipe arms, patent air lock water seal, revolving cross head fitted with steel balls and races, galvanised wire ropes and shackles and duck foot bends.

The whole shall be erected, tested and adjusted by the manufacturer.

These are best erected on the site by the manufacturer, as they are specialist items of equipment requiring careful adjustment. Pumps are normally covered by prime cost sums and are installed by the manufacturer.

Media for filters

The media for biological filters shall be air-cooled blast furnace slag or a natural hard stone such as granite, whinstone or basalt, providing that in

Filter media generally consists of the most suitable local material such as clinker, slag, limestone or granite. The

all cases the material shall conform in every respect with the requirements of B.S. 1438, including the sodium sulphate soundness test and all other chemical tests referred to in that Standard and in B.S. 1047, where applicable. Sample loads of media shall be delivered to the site in advance of the main deliveries for approval by the Engineer.

The medium in the bottom 300 mm (12 in.) layer of the filter shall be 100 mm (4 in.) nominal medium kept within the following grading limits:

Passing 150 mm (6 in.) sieve	100 per cent
Passing 100 mm (4 in.) sieve	95–100 per cent
Passing 75 mm (3 in.) sieve	0– 35 per cent
Passing 60 mm (2½ in.) sieve	0– 5 per cent

The remainder of the medium shall be 50 mm (2 in.) nominal medium kept within the following grading limits:

Passing 60 mm (2½ in.) sieve	100 per cent
Passing 50 mm (2 in.) sieve	85–100 per cent
Passing 35 mm (1½ in.) sieve	0– 30 per cent
Passing 25 mm (1 in.) sieve	0– 5 per cent

The 'index of flakiness' of the 100 mm (4 in.) and 50 mm (2 in.) nominal media shall not exceed 17 per cent and their 'index of elongation' shall not exceed 35 per cent, when determined in the manner described in Appendix D of B.S. 1438.

grading of the media varies from 25 mm (1 in.) to 100 mm (4 in.) in size and the gradings given in the accompanying specification clauses have been extracted from B.S. 1438.

A common depth of filter is 2 m (6 ft). They are often circular in shape and up to 33 m (110 ft) in diameter.

B.S. 1438: Media for Biological Percolating Filters, specifies requirements for durability, grading of sizes, shape and cleanness.

The Water Pollution Research Laboratory has recently experimented satisfactorily with plastic media.

Testing of filter media

The Contractor shall, as and when required by the Engineer or his representative, carry out grading analyses, elongation tests and flakiness tests of the filter media by the methods described in B.S. 1438. The Contractor shall supply all the necessary equipment and keep records of the results of the tests.

The following schedule gives the relevant sizes and gauges of media.

The Contractor is usually required to carry out tests on the media in accordance with B.S. 1438. Sometimes the Engineer specifies the equipment which the Contractor is to supply, such as perforated-plate type sieves, thickness gauges, length gauges and a balance, often weighing up to 45 kg (100 lb) and sensitive to 0·03 kg (1 oz), complete with weights.

Nominal size of medium	*Size of pieces in sieved fraction*	*Thickness gauge*	*Length gauge*
100 mm (4 in.)	Passing 150 mm (6 in.), retained on 100 mm (4 in.)	68 mm (2·70 in.)	202 mm (8·10 in.)
	Passing 100 mm (4 in.), retained on 75 mm (3 in.)	52 mm (2·10 in.)	158 mm (6·30 in.)
50 mm (2 in.)	Passing 75 mm (3 in.), retained on 50 mm (2 in.)	37 mm (1·50 in.)	117 mm (4·50 in.)
	Passing 50 mm (2 in.), retained on 40 mm (1½ in.)	26 mm (1·05 in.)	79 mm (3·15 in.)

Placing media in filters

The Contractor shall take special care to prevent any damage being caused to under-drains or other parts of the filter when placing media in the filter. All filter media shall be screened or hand-forked on site to remove dust and undersized pieces.

The placing of the media must be done with care to avoid damage being caused to the under-drains, the structure of the filter or the media itself.

Specification clauses cover-

For a depth of 300 mm (12 in.) above the under-drains or tiles, the medium shall be conveyed in wheelbarrows and spread by hand, but above that level the Contractor will be permitted to use narrow gauge light track and small tipping wagons. Alternatively the Engineer may consider the use of other lightweight appliances above the lowest 600 mm (2 ft) of medium. Media shall not be tipped direct from trucks or lorries into the filters.

ing most other constructional work in filters and other sewage works structures will be found in the relevant chapters dealing with earthwork, concrete, brickwork, masonry, etc.

Fibreglass scumboards

Fibreglass scumboards shall consist of a 375 mm × 25 mm (15 in. × 1 in.) angle with a small bulb on the edge of the 375 mm (15 in.) leg, fixed to N 4 aluminium-alloy brackets, 15 mm ($\frac{1}{2}$ in.) thick. The fibreglass shall be 2-ply chopped strand glass-fibre mat, with a minimum density of 0·6 kg/m² (2 oz/ft²) for each ply, with a tissue reinforced resin-rich exterior to all surfaces and a minimum overall resin/glass rate of 3:1. The resin shall be suitable for continuous immersion in sewage with a pH value of between 7·0 and 8·0.

Fibreglass is now beginning to replace timber for scumboards and baffle boxes in settling and other tanks. Typical fibreglass specification requirements are detailed.

Sewage screens

Manually-raked sewage screens shall be 1·65 m (5 ft 6 in.) wide and shall consist of mild steel flat bars 40 mm × 15 mm ($1\frac{1}{2}$ in. × $\frac{1}{2}$ in.) with 20 mm ($\frac{3}{4}$ in.) clear spaces between them, set at an angle of 45° and turned over at the top to facilitate raking, with a transverse bar fixed at each end to maintain the bar spacing. The screens shall rest in 75 mm × 75 mm × 10 mm (3 in. × 3 in. × $\frac{3}{8}$ in.)

This chapter closes with a specification clause covering a small manually-raked sewage screen, of a type frequently encountered in small sewage works, to indicate a suitable method of approach.

steel angles, built into walls, to permit easy withdrawal. The height of the screen measured vertically shall be 2·15 m (7 ft). All parts shall be heavily galvanised after fabrication.