

SECTION R3

Reinforced Concrete Pipe Culverts

R3 01 Scope

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labor and in performing all operations in connection with constructing reinforced concrete pipe culverts, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification and applicable drawings.

R3 02 Materials

1. Precast Reinforced Concrete Pipes with dimensions, materials and manufacture shall comply as follows:-

2. **Cement:** Portland cement shall conform to the requirements of BS12 Part 2 (1971) Portland cement (ordinary and rapid-hardening) or to the requirements of BS4027 Part 2 (1972) Sulphate resisting Portland cement or AASHTO M85-74 Type V for High Sulphate Resistance Cement. Unless otherwise specified on the Drawings or in the Special Specification of Particular Application Type V, High Sulphate Resistant Portland Cement, as AASHTO M85-74 shall be used.

3. **Steel Reinforcement:** Reinforcement may consist of steel wire, fabric or bars conforming to the following standards:

- BS4449 (1969). Hot Rolled Steel Bars for the Reinforcement of Concrete.
- BS4483 (1969). Steel Fabric for the Reinforcement of Concrete.
- AASHTO M32-74. Cold Drawn Steel Wire for Concrete Reinforcement.
- AASHTO M55-73. Welded Steel Wire Fabric for Concrete Reinforcement.
- AASHTO M31-74. Deformed and plain Billet Steel Bars for Concrete Reinforcement.

4. **Aggregate:** Aggregates shall conform to the requirements of the structural concrete section of this Specification, except that the requirement for grading need not apply.

5. **Mixtures:** The aggregates shall be so sized, so graded and proportioned, and thoroughly mixed in a batch with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the test requirements. In no case, however, shall the proportion of Portland cement in the mixture be less than 7 standard bags (350kg) per cubic meter of concrete.

R3 03 Manufacturing requirements

1. Reinforced concrete culvert pipes shall conform to the requirements of AASHTO M 170-74 except as modified herein.

2. **Dimensions and Strength Test Requirements:** Shell thicknesses, the amount of circular reinforcement and the strength per linear meter for the various sizes of pipe shall conform to the minimum requirements listed in Table R 3/1.

TABLE R3/1
REINFORCED CONCRETE PIPES FOR CULVERTS
DIMENSION AND STRENGTH TEST REQUIREMENTS

Normal Size(1) Internal Diameter		Minimum Shall Thickness	Minimum Circular Reinforcement(2)		Minimum Strength AASHTO M170	
Cms.	Inches		Square Cms. Per Linear Meter	Square Inches Per Linear Foot	At 0.01 Inch Crack	Ultimate Load
		Pounds Per Linear Foot			Pounds Per Linear Foot	
30	12	4.0	1.7	0.08	2250	3500
37.5	15	4.5	2.3	0.11	2625	4065
45	18	5.0	3.0	0.14	3000	4500
60	24	6.0	4.2	0.20	3000	5000
75	30	7.2	5.9	0.28	3375	5750
90	36	8.4	8.0	0.38	4050	6600

(1) Nominal size for any given single pipe installation may be either the metric or imperial size but not mixed.

(2) Single line reinforcement.

3. **Reinforcement:** Each line of reinforcement shall be assembled into a cage, which shall contain sufficient longitudinal bars or members extending through the barrel of the pipe to maintain the reinforcement rigidly in exact shape and correct position within the form. If the splices are not welded, the reinforcement shall be lapped not less than 30 diameters for bars and 40 diameters for cold-drawn wire. If welded, the member at either a welded splice or intersection shall develop a tensile strength of not less than 3,700 kgf/cm². The spacing centres of adjacent rings of the circumferential reinforcement shall not exceed 10cm. The circumferential reinforcement shall be located midway between the inner and outer surfaces of the pipe within a tolerance of ± 6 mm.

4. **Joints:** The ends of reinforced concrete culvert pipes shall be the ogee or spigot and socket types and of such design that when laid the joints shall form a continuous conduit with a smooth and uniform interior surface.

5. **Internal Diameter:** Variations of the internal diameter shall not exceed ± 1 per cent of the nominal size specified.

6. **Absorption:** The water absorption of the concrete pipe shall not exceed 6 per cent of the dry weight, when tested in accordance with AASHTO T33.

7. **Curing:** Pipes shall be subjected to anyone of the methods of curing described in the following paragraphs (1) to (3) or to any other method or combination of methods, approved by the Engineer's Representative that will give satisfactory results, provided that no pipe shall be used within a period of 14 days after curing. All pipes shall be marked with the date of casting.

- (1) **Steam Curing:** Pipes shall be placed in a curing chamber, free from outside draughts, and cured in a moist atmosphere, maintained at a temperature between 38 and 54°C by the injection of steam for a period of not less than 24 hours or, when necessary, for such additional time as may be needed to enable the pipe to meet the strength requirements. When a curing chamber is not available, pipes may be placed in an enclosure of canvas or other closely woven material and subjected to saturated steam at the temperature and for the time specified above. The enclosure shall be so erected as to allow full circulation of steam around the entire pipe. The interior surfaces of the curing room or canvas jackets and the surfaces of the pipes shall be entirely moist at all times.
- (2) **Water Spray Curing:** Under the conditions of enclosure prescribed in (1) above, pipes may be cured by subjecting them to a continuous or frequently applied fine spray of water in an enclosure maintained at a temperature of not less than 21 ° C for a period of not less than 72 hours, or such additional time as may be necessary to meet the strength requirements.
- (3) **Saturated Cover Curing:** The sides and top of each pipe may be covered with heavy hessian or other suitable material, saturated with water before applying and kept saturated with water at a temperature of not less than 21°C for 72 hours, or such additional time as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe. If the temperature of the water is less than 21°C the curing period shall be increased as may be necessary to meet the strength requirements.

8. **Workmanship and Finish:** All pipes shall be substantially free from fractures, large or deep cracks, honeycombing, open texture, spalls and surface roughness. The planes of the ends of the pipe shall be perpendicular to the longitudinal axis.

9. **Inspection:** The quality of all materials, the process of manufacture and the finished pipes shall be subject to inspection, test and approval at the place of manufacture. The Contractor shall make the necessary arrangements with the manufacturer to set aside in a separate area all pipes for which he desires approval.

- (1) **Test Specimens:** Pipes for the purpose of tests shall be furnished without charge by the Contractor and will be selected at random by the Engineer's representative; they shall be pipes which would not otherwise be rejected under this Specification. The number of sections required for test will not be more than 2 per cent except that at least one of every size will be selected.
- (2) **Test Equipment:** If the manufacturer has equipment for conducting the crushing strength test, the Contractor shall make the necessary arrangements to have the required tests conducted in the presence of the Inspector designated by the Engineer's Representative. If the testing facilities are not available at the point of manufacture, the Contractor shall make the necessary arrangements to deliver, at no cost [0 the Employer, the pipe sections selected by the Inspector to a laboratory approved by the Engineer.
- (3) **Re-test:** Should any of the test specimens provided in accordance with the requirements listed in paragraph (1) above fail to meet the test requirements, the Contractor will be allowed a re-test on two additional specimens for each specimen that failed, and the pipe will be acceptable only when all of these retested specimens meet the strength requirements.

10. **Rejection:** Pipes shall be subject to rejection on account of failure to conform to any of the above specification requirements or on account of any of the following:-

- (1) Fractures or cracks passing through the shell, except that a single end crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end crack that does not exceed the depth of the joint exists in more than 10 per cent of the pipes inspected, however, the defective pipes shall be rejected.
- (2) Defects that indicate imperfect mixing and moulding.
- (3) Surface defects indicating honeycombing or open texture and exposure of reinforcement including rust marks caused by inadequate concrete cover.
- (4) Spalls deeper than one half the depth of the joint or extending more than 10cm around the circumference. If spalls not deeper than one half of the joint or extending not more than 10cm around the circumference exist in more than 10 per cent of the pipes, however, the defective pipes shall be rejected.
- (5) Misplaced reinforcement already exposed or verified by checking with an approved concrete reinforcement cover meter.

R3 04 Installation

1. **Temporary Stream Flow:** The Contractor shall provide, as may be necessary, for the temporary diversion of water in order to permit installation of culverts in the dry.

2. **Multiple Pipe Culverts:** Where multiple lines of pipe are used, they shall be spaced far enough apart to permit thorough tamping of the earth between the pipes. To this end, the adjacent sides of the pipes shall be at least half the nominal pipe diameter apart.

3. **Laying:** Reinforced concrete pipes shall be laid in a trench excavated to the lines and grades established by the Engineer's Representative. The trench shall be graded to afford a firm and uniform bearing throughout the entire length of the pipe. Holes for sockets shall be dug if necessary.

Where solid rock is encountered, it shall be removed below grade and the trench backfilled with sand or gravel in such a manner as to provide a compacted earth cushion with a thickness under the pipe of not less than 4cm per meter of height of fill over the top of the pipe, with a minimum allowable thickness of 20cm. Where a firm foundation is not encountered, due to soft, spongy or other unsuitable material, all such unsuitable material under the pipe and for a width of not less than one diameter on each side of the pipe shall be removed and the space backfilled with sand or gravel, properly compacted to provide adequate support for the pipe.

4. **Bedding:** Immediately following excavation of the trench, pipes shall be laid and jointed, except when shown otherwise on the Drawings, on pipe bedding material complying with the following specification.

Pipe bedding material shall be excavated material from the pipe trench or other material having a grading within the range given in Table R3/2 and which has a compaction fraction value of 0.02 or less when tested as specified below.

TABLE R3/2
PIPE BEDDING MATERIAL

U.S. Sieve Size		Per Cent Passing by Weight
mm	Imperial	
37.5	1½in	100
19.0	¾in	95-100

The following apparatus shall be used for testing:

- (i) Open ended cylinder 25cm long and 15cm diameter.
- (ii) Metal rammer with a striking face 4cm diameter and of total weight 1 kg.

Stand the cylinder on a firm flat surface. Using a sample of material having a moisture content equal to that of the material at the time of use, pour the sample of material into the cylinder without supplementary compaction and strike off the material level with the top of the cylinder. Lift the cylinder clear of its contents and place on a fresh area of flat surface. Replace about one quarter of the material in the cylinder and tamp vigorously until no further compaction is evident. Repeat this process quarter by quarter until the whole of the material measured loose in the cylinder is compacted.

The final measurement from the top of the cylinder to the compacted surface divided by the height of the cylinder is the compaction fraction value.

Brick or hard material shall not be placed under the pipes for temporary support except when used on concrete beds as specified in Clause R4 16.

Pipes shall be laid so that each one is in contact with the bed throughout the length of its barrel, bedding material being scraped away at each socket in the case of socketed pipes so that the socket does not bear on the bed.

Where a concrete bed, haunch or surround is specified it shall be constructed to the dimensions shown on the Drawings or as Clause R4 16 with Concrete Class 230 as specified in Table B8/5, Section B8.

The method of supporting pipes and placing concrete shall be as Clause R4 16. The upper surface of the concrete shall be struck off with a wooden screed or template and neatly finished off and in no instance shall concrete be thrown directly on pipes.

5. Jointing of Pipe Culverts: Proper facilities shall be provided for lowering sections of pipe into trenches. The pipe shall be laid carefully to the lines and grades given and the sections fully and closely jointed by means of stiff cement mortar to form a durable watertight joint.

Cement mortar shall consist of one part by volume of sulphate resistant Portland cement as specified for Materials in Clause R3 02 and two parts by volume of natural sand or crushed natural stone sand or a combination of both as specified in BS1200: (1976): Building Sands from Natural Sources. The constituent materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only as and when required, and any mortar which has begun to set or which has been

mixed for a period of more than 30 minutes shall be rejected. All parts of the pipe to be in contact with mortar shall be washed clean and thoroughly wetted to ensure proper bond.

When the spigot and socket type of joint is used, the first pipe (down stream) shall be bedded to establish line and grade with the socket upstream. The interior surface of the socket shall be thoroughly cleaned with a wet brush and the lower portion filled with stiff mortar of sufficient thickness to make the inner surface of the abutting sections flush and even when the pipes are laid. The spigot end of the second pipe shall be thoroughly cleaned with a wet brush and uniformly matched into the socket so that the sections are closely fitted. The annular space in the socket shall then be filled with mortar and the inner surface of the pipe at the joint brushed smooth.

In jointing ogee pipes, the ogee or rebated joint of each pipe shall be thoroughly wetted immediately before jointing together and buttered with a layer of freshly mixed cement mortar as above. The pipes shall be brought to proper line and level and the joints thrust securely together. All surplus mortar exuding from the interior and exterior faces of the joints shall be cleaned off and every precaution shall be taken to ensure that no further movement is applied to the pipe. All pipes shall be kept free from dirt by means of a wooden disc with a rod attached being worked inside the pipe during jointing. All joints shall be protected against direct sunlight and wind.

After the pipe joints have been made and inspected, the concrete mat shall be thoroughly washed and cleaned and the remainder of the bedding concrete (and of the haunching and surrounding concrete where required) shall be placed and consolidated under and around the pipeline in such a manner as not to cause any damage or disturbance to the pipes or joints. When specifically required in the Special Specification of Particular Application, external bands at the joints shall be placed as specified therein. The completed pipe joints shall be immediately protected from air and sun with an initial covering of moist earth, sand, canvas or hessian. If not backfilled at once, the initial covering shall be kept moist for at least 48 hours. In order to prevent the mortar from setting too rapidly, the ends of the pipe shall be covered in such a manner as to prevent air flowing during the time the mortar is in a plastic condition.

In the case of larger diameter culverts the Engineer's Representative may direct that the pipes shall be fitted together tightly by a winch.

Alternatively, ogee joints may be filled with approved preformed joint filler, in which case the inside faces of the tongue and groove shall receive a coat of approved bituminous compound immediately before jointing. The inside of the joint must then be sealed with an approved cement bitumen mix or plastic filler to the satisfaction of the Engineer's Representative.

The interior of the pipe shall be kept free from all dirt, excess mortar and other foreign material as the pipe laying progresses and left clean at the completion of the culvert. Any pipe which is not in true alignment, or is damaged, shall be taken up and re-laid at the Contractor's expense.

No pipe shall be laid which is cracked, has internal projections, is spalled or damaged, and all such sections of pipe shall be permanently removed from the Works.

6. Backfilling of Trenches: After the final inspection of the jointing of the pipes, backfilling shall proceed immediately as specified in Clause R4 21. The bedding material, or where none is specified, the approved backfill material as specified in Clause R4 21, shall be brought up equally on both sides of the pipe, first to the level of the centre of the pipeline

and then to a height of 30cm above the top of the pipe barrel. The bedding or backfill material, up to the level of 30cm above the top of the pipe barrel, shall be placed in layers each not more than 15cm thickness and shall be carefully compacted for the full width of the trench with unpowered hand tools. Tire backfill material above the level of 30cm above the pipe barrel shall be as specified in Clause R4 21 and shall be placed and compacted as specified in Section R5.

7. Construction Plant: Movement of construction equipment over a culvert shall be at the Contractor's risk. Any pipe injured thereby shall be repaired or replaced at the opinion of the Engineer's Representative and at the Contractor's cost.

R3 05 Headwalls

Where indicated on the Drawings, the ends of the pipe culverts shall be protected by concrete or masonry headwalls constructed as shown on the Drawings. When headwalls are constructed, the ends of the pipes shall be neatly cut off flush with the outside face of the headwalls.

R3 05A Reinstatement of road surfaces

Where the surface of any road, footpath or verge has been disturbed it shall be fully reinstated by the Contractor to the satisfaction of the Engineer's Representative and any owner concerned.

R3 06 Measurement

1. The unit of measurement for reinforced concrete pipe shall be the actual length placed in meters, measured along the slope to the nearest 0.1m, except that no payment will be allowed for pipes placed in excess of the length ordered by the Engineer.

2. The unit of measurement for concrete in headwalls shall be the cubic meter.

3. The excavation and backfill involved in installing the pipes, including the provision and placing of sand or gravel for pipe foundations, when necessary, to provide adequate support for the pipe where a firm foundation is not encountered, as specified above, shall be measured and paid for as provided in Section R5.

R3 07 Payment

Payment will be made at the price tendered. per cubic meter for excavation, at the price tendered per linear meter for reinforced concrete pipes and at the price tendered per cubic meter for concrete.

SECTION R3A

Plain concrete pipe culverts

R3A 01 Scope

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labor, and in performing all operations in connection with constructing plain concrete pipe culverts, complete, subject to the terms and Conditions of Contract and in strict accordance with this Section of the Specification and the applicable Drawings.

R3A 02 Earthworks

The excavation required shall be performed in accordance with Section R5 except that the trench width shall be the net width of the pipe plus concrete surrounding as shown on the Drawings.

R3A 03 Pipes

Concrete pipes and specials shall comply with the requirements of BS556 Part 2 (1972) Concrete cylindrical pipes using sulphate resisting cement as AASHTO M85-74 Type (V), unless otherwise provided in the Special Specification of Particular Application.

R3A 04 Laying, bedding and jointing pipes

Plain concrete pipes shall be laid, bedded and jointed as specified for Reinforced Concrete Pipes in Clause R3 04, except that the jointing of spigot and socket concrete pipes shall be as specified in Clause R4 17.

R3A 05 Reinstatement of road surfaces

Where the surface of any road, footpath or verge has been disturbed it shall be fully reinstated by the Contractor to the satisfaction of the Engineer's Representative and any owner concerned.

R3A 06 Measurement

The unit of measurement for pipe culvert shall be as follows:

1. For drainage excavation the cubic meter in accordance with Clause R5 16-3.
2. For the pipes the linear meter.
3. For concrete the cubic meter.

R3A 07 Payment

Payment will be made at the price tendered per cubic meter for drainage excavation, at the price tendered per linear meter for pipes and at the price tendered per cubic meter for concrete.

SECTION R3B

Corrugated Metal Pipe Culverts

R3B 01 Scope

The work covered by this Section of the Specification consists in the furnishing of an plant, equipment, materials and labor and in performing all operations in connection with constructing corrugated metal pipe culverts, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

R3B 02 Earthworks

The earthworks required shall be carried out in accordance with the provisions of Section R5.

R3B 03 Materials

Corrugated metal pipe culverts shall be made of corrugated steel pipe in accordance with AASHTO M36-74 from steel sheets conforming to AASHTO M218-74.

The 'pipe' shape shall be circular, pipe-arch, underpass or arch appropriate for the size required and of nestable or multi-plate construction as shown on the Drawings. Multiplate pipes shall be joined by Galvanized bolts and nuts specially shaped to suit the corrugations. Where required by the Engineer, pipes shall be supplied with a factory applied bitumen coating. Where appropriate, pipes shall be supplied with the appropriate bevel and skew or combination thereof to suit the embankment side slope and culvert skew.

R3B 04 Installation

All pipes shall be laid, bedded and jointed in accordance with the manufacturer's recommendations, including any strutting. Where required by the Engineer's Representative the pipes shall be given an additional coating of bitumen on site, particularly at joints.

Multiple installation shall be laid with centre lines parallel. The clear distance between adjacent 'pipes' shall not be less than that recommended by the manufacturer.

Where shown on the Drawings, headwalls and wing walls shall be constructed of concrete or riprap in accordance with Clause B8 07 or Section B19, respectively,

Backfilling shall be carried out in accordance with Clause R3 04-6.

Backfilling material shall be as Clause R4 21. There shall be a cover of at least 50cm over the crown of any pipe, before construction equipment is driven over it.

R3B 05 Foundation bed

The pipes shall be placed on the excavated bed which shall have a uniform density so that the pipes are uniformly supported. Compaction shall conform to the requirements of Clause R5 11-4.

Where ordered by the Engineer's Representative the pipes shall be placed on a sand bed of approved material.

R3B 06 Reinstatement of road surfaces

Where the surface of any road, footpath or verge has been disturbed it shall be fully reinstated by the Contractor to the satisfaction of the Engineer's Representative and any owner concerned.

R3B 07 Cleaning pipe culverts

On completion all metal pipe culverts shall be washed with water and left clean and free from obstructions.

R3B 08 Measurement

The unit of measurement for corrugated metal pipe culverts shall be the linear meter measured in place in accordance with the applicable drawings and/or directions of the Engineer's Representative.

Sandbed where ordered by the Engineer's Representative shall not be measured separately, but shall be deemed to be included.

R3B 09 Payment

Payment shall be made in accordance with the unit prices of the various items stated in the Bill of Quantities and shall constitute full compensation for furnishing all equipment, plant, materials and labor, including any necessary earthwork excavation and backfill, provision of sandbed where ordered, and for performing all operations in connection with the construction of corrugated metal pipe culverts in accordance with this Section.