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KERAJAAN MALAYSIA
JABATAN KERJA RAYA MALAYSIA

# STANDARD SPECIFICATION FOR ROAD WORKS

## Section 3: Drainage Works



KETUA PENGARAH KERJA RAYA
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# FOREWORD

As practices in road construction change over time, it is imperative for Jabatan Kerja Raya Malaysia (JKR) to continuously update and improve their standard specifications. These new specifications are not only aimed at keeping abreast with current technologies but also helping in improving the quality of constructed product. In unison, these new specifications have a significant positive impact on the construction industry especially with the incorporation of new products and technologies.

Standard Specification for Road Works is an essential component in the road infrastructure construction industry. This specification provides an improved guidance in the material selection and the production of good quality workmanship and products, based on current best practices. The purpose of this standard specification is to establish uniformity in road works to be used by road designers, road authorities, manufacturers and suppliers of road related products.

This document "Standard Specification for Road Works - Section 3: Drainage Works" is a part of a series of improved specifications in the Standard Specification for Road Works. The compilation of this document was carried out through many discussions by the technical committee members. Additionally it has been presented at a technical workshop held on 16th July 2008. Feedbacks and comments received were carefully considered and incorporated in the specification where appropriate.

This Specification had also been presented in the *Mesyuarat Jawatankuasa Spesifikasi Piawai JKR bagi Kerja-kerja Jalan* Bil. 3/2012 on 11th July 2012 and finally approved in the *Mesyuarat Jawatankuasa Pemandu Pengurusan* Bil. 18/2013 on 3rd September 2013.

This document will be reviewed and updated from time to time to cater for any changes on policies and current requirements. In this respect, any comments and feedback regarding this specification should be forwarded to Unit Standard & Spesifikasi, Cawangan Kejuruteraan Jalan & Geoteknik.



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# ACKNOWLEDGEMENT

This Standard Specification for Road Works - Section 3: Drainage Works has been prepared by a technical committee comprised of the following members:

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## 3.1 GENERAL

This work shall consist of the construction of surface drains, subsoil drains, pipe culverts, box culverts, sumps and other drainage structures in accordance with this Specification or as directed by the S.O.. Drainage works shall be constructed to the lines, levels, grades and cross-sections shown on the Drawings or as directed by the S.O.

## 3.2 EXCAVATION AND BACKFILLING FOR DRAINAGE WORKS

### 3.2.1 Description

This work shall consist of excavation for the construction of surface drains, subsoil drains, cast in site box culverts, and other drainage structures, pipe culverts, unless otherwise provided in the relevant works Specification, and shall include furnishing, placing, compacting and shaping foundation bedding materials, backfilling excavations against completed structures with suitable material or granular backfill where specified, and the removal and disposal of all excess excavated material, in accordance with this Specification and as shown on the Drawings and as required by the S.O.



### 3.2.2 Materials

3.2.2.1 Excavation

Material excavated shall be classified as common excavation, hard material or rock as defined in **Section 2-Earthworks** of this Specification.

3.2.2.2 Granular Bedding Material

Granular bedding material for the foundations of structures shall be suitably graded broken rubble, crushed stone, crushed gravel, sand or other material as specified on the Drawings or as required by the S.O.

3.2.2.3 Concrete Bedding

Concrete bedding or blinding for the foundations of structures shall conform to the requirements of **Section 9-Concrete** of this Specification for the class of concrete specified on the Drawings or required by the S.O.

3.2.2.4 Ordinary Backfill Material

Ordinary backfill material shall be suitable material as defined in **Section 2-Earthworks** of this Specification.

3.2.2.5 Granular Backfill Material

Granular backfill material shall be sand, crushed stone; crushed gravel or a mixture of crushed and natural aggregates, shall be essentially free from vegetative and other organic matter and clay, and shall not contain lateritic or concretionary materials.

The material shall conform to the following physical and mechanical quality requirements:

i) the fines shall be non-plastic;

ii) sand shall have a gradation conforming to the envelope shown in Table 3.1;

**TABLE 3.1 - GRADING LIMITS FOR SAND BACKFILL**

| B.S. Sieve Size | % Passing By Weight |
|---|---|
| 10.0mm | 100 |
| 5.0mm | 90 – 100 |
| 1.18mm | 45 – 80 |
| 300µm | 10 – 30 |
| 150µm | 2 – 10 |

iii) material other than sand shall have a gradation conforming to one of the envelopes shown in Table 3.2

**TABLE 3.2 - GRADING LIMITS FOR GRANULAR BACKFILL OTHER THAN SAND**

| B.S. Sieve Size | % Passing By Weight | | |
|---|---|---|---|
| | A | B | C |
| 37.5mm | 100 | - | - |
| 28.0mm | 70 – 100 | 100 | - |
| 20.0mm | 60 – 90 | 70 – 100 | 100 |
| 10.0mm | 45 – 75 | 45 – 75 | - |
| 5.0mm | 30 – 60 | 35 – 65 | 45 – 75 |
| 2.0mm | 20 – 50 | 25 – 50 | 30 – 60 |
| 425µm | 10 – 30 | 10 – 30 | 15 – 35 |
| 75µm | 0 – 2 | 0 – 2 | 0 – 2 |

3.2.2.6 Concrete Backfill

Concrete backfill where specified shall be of the grade as shown on the Drawings and shall conform to **Section 9-Concrete** of this Specification.

## 3.2.3 Excavation

The Contractor shall notify the S.O. sufficiently in advance of the beginning of any excavation so that cross-section elevations and measurements may be taken of the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the S.O.

Trenches and foundation pits for structures and underdrains shall be excavated to the lines, grades and levels as shown in the Drawings or as directed by the S.O.. Excavations must be kept free from water and temporary drains, sumps and pumps shall be provided when necessary. The rate of excavation, temporary shoring and backfill shall be approved by the S.O.. The levels of the bottoms of footings shown in the Drawings are approximate only and the S.O. may order in writing such changes in the dimensions or levels of footings as may be deemed necessary to secure a satisfactory foundation.

Boulders, logs and other objectionable materials encountered in excavation shall be removed.

After each excavation is completed the Contractor shall notify the S.O. to that effect and no footing, bedding material or structure shall be placed until the S.O. has approved the depth of excavation and the type of the foundation material as shown on the Drawings.

Rock and other hard foundation material shall be cleared of all loose materials and cut to a firm surface, either level or stepped or serrated, as shown in the Drawings or directed by the S.O.. All seams and crevices shall be cleared out and grouted with Portland cement grout at the time the footing is placed.

All loose and disintegrated rocks and thin strata shall be removed. When the footing is to rest on material other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall be deferred until just before the footing is to be placed. When, in the opinion of the S.O., the foundation material is unsuitable, the Contractor shall remove and replace with suitable material or concrete as specified in the Drawings or as directed by the S.O.. If foundation fill material is required it shall be placed and compacted in layers not more than 150mm thick or as directed by the S.O.. Compaction by tamping, rolling and vibration shall be carried out to achieve a minimum relative density of 90% (cohesive material) or 95% (cohesionless material) of Maximum Dry Density (MDD).

All excavation surfaces and surfaces of backfill material against which concrete is to be placed shall be even and firm and true to line and level.

All excavated materials, so far as suitable, shall be utilized as backfill or embankment. The surplus material, whether or not temporarily allowed to be placed within a stream area, shall be finally disposed of in such a manner as not to obstruct the stream nor otherwise impair the efficiency or appearance of the works, nor is it to endanger the partly finished structure.

Excavated materials suitable for use as backfill may be deposited by the Contractor in storage piles at points convenient for rehandling of the material during the backfilling operation.

Excavated materials shall be deposited in such places and in such a manner as not to cause damage to highway, services or property either within or outside the road reserve, and so as to cause no impediment to the drainage of the Site or surrounding area.

### 3.2.4 Backfilling with Ordinary or Granular Backfill Materials

All spaces excavated under this Specification and not occupied by a permanent structure shall be backfilled. Backfill material shall be free from large lumps, wood and other extraneous material.

Backfills not within the embankment areas shall be placed in layers not more than 300mm in depth (compacted measurement) and shall be compacted to a density comparable with the adjacent undisturbed material.

Backfills within the embankment areas shall be made with approved material placed in uniform layers not to exceed 150mm in depth (compacted measurement) and each layer shall be constructed in accordance with **Section 2 - Earthworks** of this Specification except that mechanical tampers may be used for compaction. Each layer of backfill shall be wetted uniformly as necessary and compacted to the same requirements as the adjacent earthwork as specified in **Section 2 - Earthworks** of this Specification. Unless otherwise approved by the S.O., hand tamping will not be accepted.

In placing backfill and embankment, the materials shall be placed insofar as possible to approximately the same height on both sides of the structure. If conditions require backfilling appreciably higher on one side, the additional materials on the higher side shall not be placed until permission is given by the S.O. or until the S.O. is satisfied that the structure has enough strength to withstand any pressure created.

Backfills for embankment shall not be placed behind the walls of box culverts until the top slab is placed for the required time and not less than three days.

Backfill and embankment behind abutments held at the top by superstructure shall be carried up simultaneously behind opposite abutments and side walls.

No backfilling shall be placed against any structure until permission shall have been given by the S.O.. Jetting of fill or other hydraulic methods involving, or likely to involve, liquid or semi-liquid pressure shall be prohibited.

Special care shall be taken to prevent any unduly high pressures against the structures.

The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be a horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled.



## 3.3 CHANNEL EXCAVATION

### 3.3.1 Description

This work shall consist of excavation for waterway channels both inside and outside the road reserve as shown on the Drawings or as directed by the S.O. and shall include all required excavation for widening, training or permanently diverting rivers, streams and irrigation and drainage channels other than drains and ditches appurtenant to the roadway, except excavation of topsoil for use in the Works and excavation required for clearing and grubbing. This work shall also include the backfilling of old channels, haulage to their points of utilization in the Works or the removal and disposal of all excavated materials, the construction of appurtenant bunds, dikes and berms, and the shaping and finishing of all earthworks involved in the construction of channels in accordance with the required lines, levels, grades and cross-sections as shown on the Drawings or as directed by the S.O.

### 3.3.2 Materials

Channel excavation shall be classified as common excavation, hard material or rock as specified in **Section 2-Earthworks** of this Specification.

### 3.3.3 Construction Methods

All suitable materials removed from channel excavations shall be used for backfilling waterways to be abandoned and constructing bunds, dikes and other earth appurtenances as directed by the S.O.. Surplus suitable materials shall be used as far as is practicable in constructing the roadway. The Contractor shall provide borrow of satisfactory quality and approved by the S.O. should this be necessary to complete the work. Borrow which is

required to replace suitable excavated materials needed for construction which the Contractor elects to waste shall not be paid for.

Excavated unsuitable material, suitable material surplus to that needed for construction and suitable material that the Contractor elects to waste, shall be disposed of at designated areas in such a manner as to present a neat appearance and not obstruct flow in any channels, ditches or drains, nor cause damage to road works or property, all to the satisfaction of the S.O.

During construction, channel excavations shall be kept drained as far as is practicable and the work shall be carried out in a neat and workmanlike manner.

All channels and appurtenances shall be excavated and constructed to the lines, levels, grades and cross-sections shown on the Drawings or as directed by the S.O.. Excavation beyond the limits required shall not be paid for and shall be backfilled at the Contractor's expense as directed by the S.O. should he deem it necessary.

Sections of channel abandoned owing to diversions shall be backfilled as directed by the S.O.

## 3.4 SURFACE DRAINAGE

### 3.4.1 Description

Surface drains of the types shown in the Drawings shall be constructed to the lines, levels, grades and cross-sections as specified or as directed by the S.O.. Surface drains shall include interceptor drains, roadside drains, embankment toe drains, shoulder drains, bench drains, berm drains, median drains, outfall drains, cascade drains, sumps etc.

Any of the above drains may be constructed either unlined or lined using cast in situ concrete, precast or porous concrete drain sections, or stone pitching.

### 3.4.2 Surface Drain Construction

3.4.2.1 Unlined Drains

Excavation for unlined drains shall be trimmed to form a smooth, firm surface to the required lines, levels, grades, and cross-sections as specified in the Drawings or as directed by the S.O.

In case of swale, it shall be trimmed to form a smooth, firm surface to the required lines, levels, grades, cross-sections and close turfed as specified in the Drawings or as directed by the S.O.

Any areas of over excavation shall be made good to the satisfaction of the S.O., all at the Contractor's expense.

3.4.2.2 Cast In-Situ Concrete Drains

Excavation shall be carried out to the lines and levels as shown on the Drawings. Templates which may be of timber or steel shall hen be provided to ensure the thickness and shape of the concrete drains.

Concrete drain without reinforcement, the concrete shall be cast in alternate bays in 2m length. The intermediate bays shall be carried out 24 hours after the construction of the preceding sections or as directed by the S.O.. If raining, concrete drain shall be covered by necessary means or as directed by the S.O.. Construction joints shall not be formed in the inverts.

Concrete drain with reinforcement shall refer to **Section 9-Concrete** of this Specifications.

All concrete shall be grade 20 concrete unless otherwise specified and shall conform to the requirements of **Section 9-Concrete** of this Specification.

Weepholes shall be installed as shown in the Drawings or as directed by the S.O. and shall comply with Sub-Section 3.7.3.

3.4.2.3 Precast Concrete Drain Sections

Precast concrete block inverts shall be of the shapes and dimensions as shown on the Drawings and shall be of grade 20 concrete unless otherwise specified and shall conform to the requirements of **Section 9-Concrete** of this Specification.

The precast concrete drain sections shall be manufactured using good quality moulds and the finished product shall be round and have smooth inside surfaces all to the approval of the S.O.

Ready made or alternative precast concrete drain sections may be used subject to the approval of the S.O.. Samples of ready made drain sections shall be submitted to the S.O. for his approval before placing of orders. Notwithstanding any approval given by the S.O., any defective or broken drain section shall be replaced by the Contractor at his own expense before or after laying in position.

All precast drain units shall be of a dense and impermeable type.

Notwithstanding any approval given by the S.O., any defective or broken drain section shall be replaced by the Contractor at his own expense before or after laying in position.

Precast concrete drain sections shall be laid on concrete bedding in trenches excavated to the lines and levels as specified and jointed to produce a neat even alignment and gradient. The joint shall be grouted with 1:3 cement mortars complying with Sub-Section 3.5.2.2 and

weepholes shall be provided as specified in the Drawings or as directed by the S.O.

Mass concrete for bases shall be of grade 15 concrete unless otherwise specified and shall conform to the requirements of **Section 9-Concrete** of this Specification and to the dimensions and thicknesses as shown in the Drawings.

3.4.2.4 Stone Pitching Drains

Excavation shall be carried out to the lines and levels as specified in the Drawings.

The constituent materials and construction methods of stone pitching shall comply with the appropriate requirements of Section 3.5 of this Specification.

Weep holes shall be installed as shown in the Drawings or as directed by the S.O. and shall comply with Sub-Section 3.7.3.

3.4.2.5 Sumps

Sumps shall be constructed of brickwork or stone pitching in accordance with Section 3.6 and Section 3.5 or in-situ concrete accordance with **Section 9-Concrete** of this Specification.

Foundations to sumps shall be of concrete of a quality and dimensions indicated in the Drawings and shall finish flush with the sides unless the Drawings indicate other requirements.

3.4.2.6 Half Round Glazed Earthenware Drains

Half round glazed earthenware for surface drainage shall comply with MS 1061.



## 3.5 STONE PITCHING

### 3.5.1 Description

This work shall consist of the construction of all structures or parts of structures to be composed of stone pitching either grouted or ungrouted as shown in the Drawings or as directed by the S.O. including erosion protection works, aprons, drain linings, culvert inlets and outlets, etc. The work shall be carried out all in accordance with this Specification and to the lines, levels, grades, dimensions and cross-sections shown on the Drawings and as required by the S.O.

### 3.5.2 Materials

3.5.2.1 Stones

Stone shall be clean rough quarry stone, or pit or river cobbles, or a mixture of any of these materials, and shall be essentially free from dust, clay, vegetative matter and other deleterious materials. Individual pieces of stone shall be approximately cubical or spherical and shall have least dimensions in the range 100 to 150mm and a maximum dimension of 250mm, unless otherwise specified. The stone shall be hard, tough, durable and dense, resistant to the action of air and water, and suitable in all respects for the purpose intended.

3.5.2.2 Cement Mortar

Cement mortar, unless otherwise specified, shall contain 1 part Ordinary Portland Cement to 3 parts fine aggregate by volume. Water shall be added to the mix to produce a suitable consistency for the intended use, all to the satisfaction of the S.O.. The constituent materials of the mortar shall comply with the appropriate requirements of **Section 9-Concrete** of this Specification.

The ingredients for mortar shall be measured in proper gauge boxes and mixed on a clean boarded platform or in an approved mechanical batch mixer.

All mortar shall be used within 30 minutes of mixing and no reworking of mortar shall be permitted thereafter.

### 3.5.3 Construction Methods

3.5.3.1 Grouted Stone Pitching

Prior to constructing grouted stone pitching, the surfaces against which it is to be placed shall have been finished in accordance with the appropriate provisions of this Specification. Notwithstanding any earlier approval of these finished surfaces, any damage to or deterioration of them shall be made good to the satisfaction of the S.O. before grouted stone pitching is placed.

Construction of grouted stone pitching shall commence at the lowest part of each structure or section of a structure and continue progressively upward. Long structures such as drain linings and slope protection shall be constructed in section of practicable length, to the satisfaction of the S.O.. The surface against which the work is to be placed shall be moistened with clean water a little in advance of construction, and covered with a layer of cement mortar about 50mm thick. Stones shall then be firmly set by hand into the mortar, densely packed against adjacent stones and built up to form a stone structure of more or less uniform thickness which shall nowhere be less than 150mm (measured perpendicularly to the surface

covered). All the while that stones are being placed, all voids in the structure shall be packed solidly with mortar and stone spalls; however the surfaces of stones in the exposed faces and edges shall not be covered with mortar. The exposed surfaces and edges of the structure shall be constructed such that they have as large a proportion as practicable composed of stone faces. Weep holes shall be provided as shown in the Drawings or as directed by the S.O.

Mortar which has been mixed for more than 30 minutes shall not be used in the works. Nor shall mortar be laid against the supporting surface more than 2 minutes before pitching stone and building up the structure to full thickness is commenced on any section of the work, as the construction advances.

The work shall be carried out and finished all to the satisfaction of the S.O.

3.5.3.2 Ungrouted Stone Pitching

Where shown in the Drawings, ungrouted stone pitching shall be hand set to provide maximum interlocking effect. The stones, the largest of which shall be used at the bottom, shall be well bedded on a 75mm layer of gravel or aggregate rammed to an even surface. The whole work shall be finished to the satisfaction of the S.O.

## 3.6 BRICKWORK

### 3.6.1 Description

This work shall include the laying of brickwork to the lines, levels and grades shown in the Drawings or as directed by the S.O.

### 3.6.2 Materials

3.6.2.1 Cement

The cement, unless otherwise described, shall be Ordinary Portland Cement complying with M.S. 522 and as specified under **Section 9-Concrete** of this Specification.

3.6.2.2 Sand

Sand for mortar shall comply with M.S. 29 and as specified in **Section 9-Concrete** of this Specification.

3.6.2.3 Cement Mortar

Cement mortar shall comply with Sub-Section 3.5.2.2.

3.6.2.4 Clay Bricks

Clay bricks shall be sound, hard, well burnt, of proper size and clean and shall give a clear ring when struck. They shall be of Class 3 standard format complying with the requirements of M.S. 76. Bricks shall be obtained from manufacturers approved by the S.O.

3.6.2.5 Cement Sand Bricks

(a) All cement sand bricks shall comply with M.S. 27.

(b) Size

Cement sand bricks shall be of a nominal size as given below:

**TABLE 3.3 - NOMINAL SIZES OF CEMENT SAND BRICKS**

| Length (mm) | Width (mm) | Depth (mm) |
|---|---|---|
| 225 ± 3.2 | 113 ± 1.6 | 75 ± 1.6 |

(c) The Contractor shall only use cement sand bricks supplied by approved manufacturers or as approved by the S.O.

### 3.6.3 Construction Methods

3.6.3.1 Brick Laying

Brickwork shall be executed with cement mortar and shall be of the thickness and bonds as shown in the Drawings. Bricks shall be kept damp until used and shall be laid on a full bed of mortar. The brickwork shall be true to line and plumb, and courses shall be kept level.

The thickness of mortar joints shall not exceed 10mm and shall be such that 4 courses of brickwork forms a height of 300mm. Newly laid brickwork shall be protected from the harmful effects of sunshine, rain, running and surface water and shocks.

Any brickwork that is damaged shall be taken down and rebuilt, and the joints raked out and pointed as directed by the S.O.. Any such remedial work shall be at the Contractor's own expense.

3.6.3.2 Plastering Brickwork

All exposed brickwork surfaces shall be plastered. The plaster shall be applied generally to a minimum total thickness of 20mm unless otherwise specified in the Drawings and shall be finished to Class U3 unformed surfaces as per **Section 9-Concrete** of this Specification.

Plain plaster shall consist of 1 part masonry cement complying with M.S. 794 to 3 parts of sand by volume. Where Ordinary Portland Cement is

used, plasticizer of a type approved by the S.O. may be added to the mix in accordance with the manufacturer's instructions.

Ordinary Portland Cement and water shall comply with the appropriate requirements of **Section 9-Concrete** of this Specification.

Weep holes not more than 3 meters center to center shall be provided, unless specified in the Drawings or as directed by the S.O. and shall comply with the appropriate requirements of Sub-Section 3.7.3.

## 3.7 SUBSOIL DRAINS

### 3.7.1 Description

This work shall include the supply and installation of subsoil drains constructed in accordance with this Specification at the locations and in accordance with the lines, levels and grades as shown in the Drawings or as directed by the S.O.

### 3.7.2 Materials

3.7.2.1 Pipes

Porous concrete pipes for subsoil drains shall comply with M.S. 525.

Clay pipes for subsoil drains shall comply with B.S. 1196.

Polyvinyl Chloride (PVC) pipes for subsoil drains shall comply with Australian Standard Specification 2439 or B.S. 3656.

3.7.2.2 Filter Material

Filter material used in the construction of subsoil drains shall consist of hard, clean sand conforming to the grading limits given in Table 3.4. The material passing the 425µm sieve shall be non-plastic when tested in accordance with B.S. 1377.

**TABLE 3.4 - GRADING LIMITS FOR FILTER MATERIAL**

| B.S. Sieve Size | % Passing By Weight |
|---|---|
| 10.0 mm | 100 |
| 5.0 mm | 90 - 100 |
| 2.36 mm | 95 - 100 |
| 1.18 mm | 55 - 90 |
| 600 µm | 35 - 59 |
| 300 µm | 8 - 30 |
| 150 µm | 0 - 10 |

3.7.2.3 Filter Cloth

The synthetic filter cloth shall be a non-woven type of approved manufacture having the following properties: -

*(a) Chemical Composition Requirements*

Fibres used in the manufacture of the engineering fabric shall consist of a long chain synthetic polymer, composed of at least 85% by weight of polypropylene, ethylene, ester amide or vinylidene chloride and shall contain stabilizers and/or inhibitors added to the base plastic (as necessary) to make the fabric resistant to deterioration from ultraviolet and heat exposure.

*(b) Physical Property Requirements*

The physical properties of the filter cloth shall comply with Table 3.5.



**TABLE 3.5 - PHYSICAL PROPERTY REQUIREMENTS FOR FILTER CLOTH**

| No | Description | Test Standard | Unit | Properties |
|---|---|---|---|---|
| 1. | Tensile Strength | ISO 10319 | kN/m | > 9 |
| 2. | Tensile Elongation | ISO 10319 | % | > 40 |
| 3. | CBR Puncture Resistance | ISO 12236 | N | > 1500 |
| 4. | Cone Drop | BS 6906/6 | mm | < 27 |
| 5. | Grab Strength | ASTM D 4632 | N | > 550 |
| 6. | Nominal Mass | ISO 9864 | $g/m^2$ | > 125 |
| 7. | Thickness (2kPa ) | ISO 9863 | mm | > 1.2 |
| 8. | UV Resistance<br>- Tensile Strength<br><br>- Puncture Strength | <br>ISO 10319<br><br>ISO 12236 | <br>> 70% Strength retention after 3 months outdoor weathering<br><br>> 70% Strength retention after 3 months outdoor weathering | |
| 9. | Chemical Resistance | | No influence at pH range 2 - 13 | |

*(c) Filtration Requirement*

Equivalent opening size of the filter cloth determined by sieving as described in ASTM D422 shall be less than the eighty-five percentage size of the adjacent soil.

*(d) Permeability Requirement*

The equivalent Darcy Permeability of the filter cloth shall be greater than 10 times the Darcy Permeability of the soil to be drained or as shown in the Drawings or as directed by the S.O.

3.7.2.4 Cement Mortar

Cement mortar shall comply with Sub-Section 3.5.2.2.

3.7.2.5 Construction Methods

Excavation for subsoil drains shall be carried out all in accordance with the appropriate provisions of Sub-Section 3.2.3.

Trench shall be lined with filter cloth of 500mm minimum overlapping.

Filter material shall be placed and uniformly compacted by a suitable method approved by the S.O. to form a firm and even bedding for the pipe drain.

The pipe sections shall be set firmly against the filter material bedding with the flow lines in the design position. For pipes with mating joints, the receiving ends shall be at upgrade position, and the pipe joints shall be fully mated. For butt jointed pipes with collars, the pipe sections shall be fully contiguous, and the collars properly centered over the joints.

Joints shall be spot mortared as necessary to hold the pipe sections correctly centered and aligned, but not so as to unduly restrict the infiltration of water through the joints.

Slotted or perforated pipes shall be tightly wrapped in filter cloth such that the entire length of the mortared pipe is covered by at least 2 layers of cloth. All joints in both layers shall have an overlap of at least 100mm and joints in the outer layer shall be offset by at least 300mm from joints in the inner layer, all to the satisfaction of the S.O.

After pipe laying and, if appropriate, wrapping has been approved by the S.O., the remainder of the filter material shall be placed and uniformly compacted by a suitable method approved by the S.O. to form a dense evenly surrounding to the pipe or as specified in the Drawings. Care shall be taken that the pipe is neither damaged nor displaced.

Backfill shall then be placed and compacted in accordance with the appropriate provisions of Sub-Section 3.2.4.

### 3.7.3 Weep holes

Weep holes shall be of PVC pipes, unless otherwise specified in the Drawings. Filter materials and filter cloth of the weep holes shall comply with Sub-Section 3.7.2.2 and 3.7.2.3. Filter material shall be wrapped with filter cloth and shall be packed behind weep holes before backfilling.

## 3.8 R.C. PIPE CULVERTS

### 3.8.1 Description

This work shall comprise the supply and installation of reinforced concrete pipe culverts, inclusive of excavation, backfilling, jointing, bedding, construction of headwalls, wingwalls, aprons and sumps and channel protection works, all in accordance with this Specification and the details shown in the Drawings.

### 3.8.2 Materials

3.8.2.1 Pipes

Reinforced concrete pipes shall conform to the requirements of M.S. 881 and shall be supplied by manufacturers approved by the S.O.

Rebated pipes of diameter 600mm and above shall be internally rebated.

Collars shall be pre-cast with minimum grade 25 concrete and shall be suitably reinforced all in accordance with **Section 9-Concrete** of this Specification. The width of the collar shall be not less than 150mm and the minimum thickness shall be 50mm.

Rubber rings for spigot and socket pipes shall comply with the requirements of Type 2 as specified in B.S. 2494.

3.8.2.2 Cement Mortar

1:3 cement mortar for jointing of reinforced concrete pipes shall conform to the requirements of Sub-Section 3.5.2.2.

3.8.2.3 Bedding Material

Type A bedding shall consist of grade 20 concrete or otherwise stated in the Drawings, complying with **Section 9-Concrete** of this Specification.

Type B bedding shall consist of clean, natural sand or gravelly sand of suitable gradation and quality, approved by the S.O.. The material shall have a maximum particle size of not more than 20mm.

Bedding material shall have a gradation conforming to the envelope shown in Table 3.1 for sand and Table 3.2 (Envelope C) for granular of this Specification.

### 3.8.3 Excavation and Backfilling for R.C. Pipe Culverts

3.8.3.1 Excavation

*(a) General*

Unless otherwise directed by the S.O., prior to construction of a pipe culvert, the earthworks at the required location shall have been constructed to a level at least 600mm above the top of culvert design levels or to the top of subgrade levels, whichever is lower.

Pipe culverts specified to be constructed in trench conditions shall be excavated in accordance with Sub-Section 3.8.3.1 (b) below.

Where drainage conditions or other circumstances so require, the S.O. may direct the Contractor to construct the pipe culvert without first constructing the earthworks to the level specified above, in which case excavation and foundation preparation shall be in accordance with Sub-Section 3.8.3.1 (c) below.

*(b) Trench Method*

The trench to receive a culvert pipe shall be of sufficient width and depth to enable the placing of bedding material and construction of pipe joints in accordance with this Specification. Minimum side clearance shall be 300mm or 0.2 times diameter of culvert whichever is greater to accommodate an operator and compactor beside the pipe. In unstable soil conditions, shoring of the trench should be considered and additional trench width is required for trench wall support system. The bottom of the trench shall be trimmed to a suitably smooth plane surface which shall be kept free from water, all to the satisfaction of the S.O.

Where rock or other hard material foundation is encountered in the trench, it shall be excavated to a depth below the bottom of pipe design levels of at least 300mm or 12.5mm per 300mm of fill to be placed over the top of the pipe, whichever is greater, up to a maximum of 75% of the internal diameter of the pipe. The hard material so excavated shall be replaced with suitable material uniformly compacted in layers of not more than 150mm compacted thickness to provide satisfactory support for the pipe, all to the satisfaction of the S.O.

*(c) Open Ground Method*

Where existing ground levels are above top of bedding material design levels and firm foundation materials are encountered, excavation and foundation preparation shall be similar to that described in the trench method above. Otherwise a firm foundation plane shall be prepared, which shall be essentially free draining along the line of the culvert, by trimming the existing ground, or

such fill as it is necessary to place and compact, over a width sufficient to permit satisfactory construction of the pipe bedding, all to the satisfaction of the S.O.. Hard materials shall be excavated from the pipe foundation over a width equal to the outside diameter of the pipe to the same depth as specified in the trench method, and shall be replaced with suitable materials uniformly compacted in layers of not more than 150mm compacted thickness to provide satisfactory support for the pipe, all to the satisfaction of the S.O.

Where soft or unstable soil is encountered in the foundation, it shall be excavated over a width of at least 1.5 times the outside diameter of the pipe on each side of the culvert centre-line to the depth directed by the S.O. and replaced with suitable material uniformly compacted in layers of not more than 150mm compacted thickness to provide satisfactory support for the pipe, all to the satisfaction of the S.O.

3.8.3.2 Backfilling

Backfilling against reinforced concrete pipe culverts and their appurtenant structures shall be carried out in accordance with the construction methods described in Sub-Section 3.2.4, using material conforming to the requirements of Sub-Section 3.2.2.5. Special care shall be taken to properly compact backfill against the undersides of culvert pipes without disturbing or damaging the pipes and joints. Backfill shall be built up evenly on both sides of each pipe culvert along its entire length.

Heavy plant and equipment shall not operate within 1.5m of any pipe culvert until backfilling and, where appropriate, pavement construction has advanced to a stage which provides at least 600mm of cover to the culvert. Subject to the approval of the S.O., light compaction equipment may be operated above pipe culverts after a minimum of 300mm of cover has been placed and compacted.



## 3.8.4 Installation of R.C Pipe Culverts

3.8.4.1 General

The type, size and class of pipe to be installed at each location shall be as shown in the Drawings or as directed by the S.O.. Culverts shall not be installed at any location until the type of pipe, the exact location, the lines, levels and grades, the length of pipe and details of inlet and outlet structures and have been confirmed by the S.O.. In addition, special requirements recommended by the manufacturer with respect to assembly and installation shall be complied with. Especially where elliptically reinforced pipe sections are used, care shall be taken to ensure that the loading axes are positioned exactly vertically.

3.8.4.2 Butt Ended Pipe Culverts with Precast Concrete Collars

The pipes shall be laid on Type A bedding in conformity with the dimensions shown in the Drawing. Before placing any concrete bedding, the pipes shall be assembled complete with precast concrete collars to the correct levels and grades on pre-cast concrete spacing blocks of the same class of concrete as the bedding material and of sufficient size to eliminate any risk of settlement of the pipes before or during concreting.

All joints shall be fully mortared with 1:3 cement mortars before concreting of the cradle, all to the satisfaction of the S.O.. The concrete cradle shall be cast as one monolithic unit. Alternatively, part of the concrete cradle below the underside of the pipe may be constructed monolithically at least 24 hours before the assembly and mortaring up of the pipe sections and collars on condition that shear connectors are provided across horizontal construction joints to the satisfaction of the S.O.

During installation, the ends of the pipes shall be butted and the collar centered about the joint using wedges or other approved means. The annular shall be completely filled with 1:3 cement mortar with only sufficient water added to ensure adequate workability and the wedges removed before finally fairing the joint. Special care shall be taken to ensure that excess cement mortar is neatly cleaned off. For pipes over 900mm in diameter the jointing space shall be filled from inside the pipe after completion of embankment construction using 1:3 cement mortar. When installed, the clearance between the outer diameter of pipe and the inner diameter of collar shall be at least 20mm.

Following pipe assembly and mortaring up as above, the remainder of the cradle shall be cast monolithically, all to the satisfaction of the S.O.

Where vertical construction joints in the concrete cradle are unavoidable due to circumstances on site, transfer bars shall be provided to the satisfaction of the S.O.

Special care shall be taken when placing the concrete cradle to avoid the entrapment of air underneath the pipe. To eliminate this possibility, concrete shall be placed to one side of the pipe only until such time as the level of the concrete surface rises above the underside of the pipe on the side remote from that on which concrete is being placed. The concrete shall then be brought up at the same level on both sides of the pipe.

3.8.4.3 Rebated Pipe Culverts

The pipes shall be laid on Type A bedding in conformity the dimensions shown in the Drawings.

The method of construction shall follow that described in Sub-section 3.8.4.2 for butt ended pipe culverts for the exclusion of pre-cast concrete collars.

The rebated joint shall be internally flush and fully mortared with 1:3 cement mortar all to the satisfaction of the S.O.

3.8.4.4 Spigot and Socket Pipe Culverts

The pipes shall be laid on Type B bedding in conformity with the dimensions shown in the Drawings. The bedding material shall be accurately shaped by a template to fit the lower part of the pipe exterior for a height of at least 10% of the outside diameter of the pipe. Gaps shall be left in the bedding material and recesses dug in the earth foundation of sufficient width and depth to accommodate the socket without it resting on the bottom of the recess. The widths of the recesses in the foundation and the bedding shall both exceed the width of the socket by more than 50mm.

Jointing of the pipes shall be carried out strictly in accordance with the manufacturer's recommendations, all to the satisfaction of the S.O.

Concrete pipes as specified above shall be laid true to lines and level, to the satisfaction of the S.O.. Pipes shall be laid in an upstream direction with the sockets towards the inlet and shall rest on even foundations for the full length of the barrel. Rubber ring joints shall be installed strictly in accordance with the manufacturer's instructions. Prior to jointing, rubber rings and jointing surfaces shall be cleaned of all contaminants except for specified lubricants. The spigot of each pipe shall be inserted concentrically in the socket of the one previously laid, and the pipe then adjusted and fixed in its correct position with the spigot correctly entered in the socket.

Care shall be taken to see that the rubber ring is adequately compressed to seal the joint. All pipes shall be laid to the satisfaction of the S.O.



## 3.9 PRECAST BOX CULVERTS

### 3.9.1 Description

This work shall comprise the supply and installation of precast box culverts inclusive of excavation, backfilling, jointing, bedding, construction of headwalls, wingwalls, aprons and sumps and channel protection works, all in accordance with this Specification and the details shown in the Drawings.

### 3.9.2 Materials

3.9.2.1 Precast Box Culverts

Precast box culverts shall be of approved manufacture complying with M.S. 1293, or any equivalent alternative standard acceptable and approved by the S.O.

3.9.2.2 Cement Mortar

1: 3 cement mortar for jointing of precast box culvert sections shall conform to the requirements of Sub-Section 3.5.2.2.

3.9.2.3 Bedding Material

Precast box culverts shall be laid on Type A or Type B bedding as specified in the Drawings and as per Sub-Section 3.8.2.3.

### 3.9.3 Excavation and Backfilling

3.9.3.1 Excavation for Precast Box Culverts

Unless otherwise directed by the S.O., prior to construction of a pre-cast box culvert, the earthworks at the required location shall have been first constructed to a level at least 600mm above the top of the culvert design levels or to the top of subgrade levels, whichever is lower, and the precast box culvert shall then be constructed in a trench excavated in accordance with Sub-Section 3.8.3.1 (b).

Where drainage conditions or other circumstances so require, the S.O. may direct the Contractor to construct the precast box culvert without first constructing the earthworks to the level specified above, in which case excavation and foundation preparation shall be in accordance with Sub-Section 3.8.3.1 (c).

3.9.3.2 Backfilling

Backfilling against precast box culverts and their appurtenant structures shall be carried out in accordance with the construction methods described in Sub-Section 3.2.4, using material conforming to the requirements of Sub-Section 3.2.2.5. Special care shall be taken to properly compact backfill without disturbing or damaging the precast box culvert sections. Backfill shall be built up evenly on both sides of each box culvert along its entire length.

Unless otherwise approved by the S.O., heavy plant and equipment shall not operate within 2.0m of any pre-cast box culvert until backfilling and, where appropriate, pavement construction has advanced to a stage which provides at least 300mm of cover to the culvert.

### 3.9.4 Installation of Precast Box Culverts

The type and size of precast box culvert to be installed at each location shall be as shown in the Drawings or as directed by the S.O.. Precast box culverts shall not be installed at any location until the exact location, the lines, levels and grades, the length of culvert and details of inlet and outlet structures have been confirmed by the S.O.. In addition, special requirements recommended by the manufacturer shall be complied with.

All joints shall be fully sealed with 1:3 cement mortar, all to the satisfaction of the S.O.. In addition, a 3mm layer of 1:3 cement mortar shall be spread on top of the legs of the invert in order to ensure uniform bearing between the invert and lid.

Lifting holes shall be filled with 1: 3 cement mortar.

## 3.10 EXTENSION OF CULVERTS

### 3.10.1 Extension of Pipe Culverts

The existing wingwalls, aprons and concrete bedding shall be demolished wherever specified in the Drawings to expose the existing pipe culvert on the side(s) to be extended. The end of the existing pipe culvert to be extended shall then be wire-brushed or some other means employed to give a clean pipe end.

Extension joints shall be formed as shown in the Drawings and such material to be of a type approved by the S.O. and accordance with the manufacturer`s specification or otherwise specified in the Drawings.

Piles shall be installed as shown in the Drawings, unless otherwise directed by the S.O.

### 3.10.2 Extension of Box Culverts

The existing wingwalls, aprons and concrete bedding shall be demolished wherever specified in the Drawings to expose the existing box culvert on the side(s) to be extended. The end of the existing box culvert to be extended shall then be wire-brushed or some other means approved by the S.O. be employed to give a clean surface.

Extension joints shall be formed as shown in the Drawings and such material to be of a type approved by the S.O. and accordance with the manufacturer`s specification or otherwise specified in the Drawings.

Piles shall be installed as shown in the Drawings, unless otherwise directed by the S.O.

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