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DIVISION 2 DRAINAGE

SECTION 2.1

DITCHES AND WATERWAYS

2.1.1 GENERAL

2.1.1.1 Description

- (a) This work shall consist of constructing new unlined or lined ditches and of re grading existing unlined ditches, in accordance with this Specification, to the lines, levels and details shown on the Drawings, or as directed by the Engineer. Lined ditches shall be constructed as shown on the Drawings or directed by the Engineer.
- (b) The work also includes relocation or preservation of existing streams, irrigation canals or other waterways which unavoidably must be disturbed, temporarily or permanently, in the course of satisfactorily completing the work of this Contract.

2.1.1.2 Issue of Construction Details

Construction details of lined and unlined ditch works not included in the Contract Documents at the time of tender shall be issued by the Engineer.

2.1.1.3 Related Work Specified Elsewhere

Related work includes but is not limited to the following:

- (a) Mobilization and Demobilization : Section 1.2
- (b) Field Engineering : Section 1.9
- (c) Environmental Safeguards : Section 1.17
- (d) Mortared Stonework : Section 2.2
- (e) Culverts and Concrete Drains : Section 2.3
- (f) Excavation : Section 3.1
- (g) Fill : Section 3.2
- (h) Routine Maintenance of Pavements, Shoulders, Drainage, Road Furniture and Bridges : Section 10.1

2.1.1.4 Dimension Tolerances

- (a) Finished grades on ditch inverts shall not vary from those specified or approved by more than 3 cm at any point, and shall be sufficiently smooth and uniform to ensure the free flow of water without ponding during low-flow periods.
- (a) Finished ditch alignments and cross-section profiles shall not vary from those specified or approved by more than 5 cm at any point.

2.1.1.5 Submittals

- (a) Samples of materials to be used for ditch lining shall be submitted as specified in Article 2.2.1.5 of these Specifications.

- (b) The Contractor shall notify the Engineer of his completion of all ditch formations and no lining material shall be placed until the Engineer has approved the formation.
- (c) Before any construction work is started on any section of the Contract the Contractor shall, where applicable carry out total station surveys, tied to benchmark and setting out points, along both sides of the road and shall either accept the design drawings and original ground data shown thereon as accurate or shall submit proposed corrections to the Engineer for approval. The maximum spacing of level readings shall be 25 metres.

2.1.1.6 Work Scheduling

- (a) The Contractor shall at all times ensure adequate drainage of the work by so scheduling ditch construction that the drainage is operative before work is begun on the embankment and pavement structure. Pumping shall be carried out as necessary to prevent water ponding within the Works area. Periodic maintenance of both temporary and permanent ditches shall also be scheduled so that a free flow of water is maintained throughout the Time for Completion.
- (b) Ditches shall first be trimmed short of the approved cross-sections, and final trimming, including the repair of any damage that may have been done during the construction work, shall be carried out after the completion of all immediately adjacent or interfacing other work.

2.1.1.7 Work Site Conditions

The provisions given in Article 3.1.1.7, regarding site dewatering and maintaining on site-sanitation, shall apply.

2.1.1.8 Rectification of Unsatisfactory Work

- (a) Survey work defining existing or constructed surface profiles shall be repeated as necessary to obtain an accurate record of the physical conditions, to the satisfaction of the Engineer.
- (b) Ditch construction work which does not meet the tolerance criteria given in Article 2.1.1.4 above, or is otherwise not acceptable to the Engineer, shall be rectified by the Contractor as directed by the Engineer.

The rectification work may include:

- (i) further excavation or filling, including if necessary first backfilling the new work and re-excavating to the specified lines;
- (ii) repair or replacement of defective mortared stonework in accordance with the provisions of Article 2.2.1.8 of these Specifications;
- (c) Unsatisfactory Fill Work shall be rectified in accordance with the provisions of Article 3.2.1.8 of these Specifications.

2.1.1.9 Maintenance of Accepted Work

Notwithstanding the Contractor's obligation to carry out rectification of unsatisfactory or failed work as specified in Article 2.1.1.8 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted lined and unlined ditches throughout the remaining Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7.

2.1.1.10 Underground Utilities

The provisions specified for Excavation in Article 3.1.1.9 shall apply also to the work carried out under this Section.

2.1.1.11 Use and Disposal of Excavated Materials

The provisions specified for Excavation in Article 3.1.1. 11 shall apply.

2.1.1.12 Site Restitution and Disposal of Temporary Works

The provisions specified for Excavation in Article 3.1.1.12 shall apply.

2.1.2 MATERIALS AND QUALITY ASSURANCE

2.1.2.1 Fill

Fill used shall conform to the requirements for material properties, placing, compacting and quality assurance specified in Section 3.2 of these Specifications.

2.1.2.2 Mortared Stonework

Mortared stone ditch lining shall conform to the requirements of material properties, placing, and quality assurance specified in Section 2.2 of these Specifications.

2.1.3 EXECUTION

2.1.3.1 Setting Out of Ditches

The required locations, lengths, direction of fall, grades and discharge treatments of all ditches and the location of all associated catch pits and ditch out-falls shall be set out by the Contractor strictly in accordance with the Drawings or as instructed by the Engineer and shall be either approved or modified by the Engineer before their construction is commenced.

2.1.3.2 Construction of Ditches

- (a) Excavation, filling and trimming shall be carried out as required to re-grade both existing and new ditches to the grades shown on the construction drawings and to the profiles shown on the typical Ditch Type in Drawing, or as otherwise directed by the Engineer.
- (b) Following approval of the prepared ditch formations by the Engineer, mortared stone lining shall be constructed as specified in Section 2.2 of these Specifications.

- (c) All materials from ditch excavations shall be disposed of and leveled by the Contractor in such a manner to prevent any environmental impacts, at the locations indicated by the Engineer.

2.1.3.3 Preservation of Existing Waterways

- (a) Natural streams or channels adjacent to the works of this Contract shall not be disturbed without the approval of the Engineer.
- (b) If any excavation or dredging in the stream bed is unavoidable for the proper execution of the works, the Contractor shall, after the works are constructed, backfill all such excavations to the original ground surface or stream bed with material approved by the Engineer.
- (c) Material from foundation or other excavations shall not be deposited within waterway areas. Cofferdam materials shall be removed completely from waterway areas following construction.

2.1.3.4 Relocation of Waterways

- (a) Where embankment stabilization or other permanent works of the Contract shall unavoidably block, or partially block, any existing waterway, the waterway shall be relocated to ensure unrestricted flow past the works at all usual levels of flood. Such relocation shall be approved by the Engineer.
- (b) Such waterway relocations shall preserve the existing channel invert gradient and shall be so aligned that no detrimental scour shall be caused in either the works or adjacent properties.
- (c) The Contractor shall survey and plot cross sections of the waterway channel to be relocated and shall plot on the cross sections the details of his proposal for the work required. The Engineer shall approve or revise the Contractor's proposal before any relocation work is commenced.

2.1.4 MEASUREMENT AND PAYMENT

2.1.4.1 Measurement for Excavation

Excavation for drainage ditches and waterways shall be measured for payment as the volume of material actually removed and accepted by the Engineer, to be necessary to satisfactorily form or reform the ditches and waterways to the correct lines, levels and profiles as shown on the Drawings or as directed by the Engineer. Excavation in excess of that shown on the Drawings or directed by the Engineer shall not be measured or paid for.

2.1.4.2 Measurement and Payment of Fill

Fill used for drainage ditches and waterways shall be measured and paid for as Fill under Section 3.2 of these Specifications.

2.1.4.3 Measurement and Payment of Ditch Lining

Ditch lining for drainage ditches and waterways shall be measured and paid for as Mortared Stonework under Section 2.2 of these Specifications.

2.1.4.4 Basis of Payment

The quantities of excavation, determined as provided above, shall be paid for at the Contract Price per unit of measurement for the Pay Item listed below and shown in Bill of Quantities, which price and payment shall be full compensation for furnishing all labor, tools and equipment for the excavation of drainage ditches and waterways, for all necessary formation or foundation preparation for ditch linings, and for all other work or costs necessary for the proper completion of the work prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
2.1	Excavation for Drainage Ditches and Waterways	Cubic Metre

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SECTION 2.2

MORTARED STONEWORK

2.2.1 GENERAL

2.2.1.1 Description

- (a) This work shall consist of lining the sides or bottom of ditches and waterways, and of constructing aprons, entry pits and other similar small waterway structures with mortar cemented stone constructed on a prepared bed in accordance with these Specifications and conformity with the lines, grades, and dimensions shown on the Drawings or as directed by the Engineer
- (b) The work also involves the construction of weep holes, including the supply and installation of weep hole forms or pipes.
- (c) In some instances, where stone quality and shape are suitable and the quality of workmanship high, the Engineer may direct that Mortared Stonework be used in place of Stone Masonry for larger load-bearing structures such as slab culverts, culvert headwalls and retaining walls.
- (d) For projects on which Soil Cement Base has been specified, the Engineer may approve the use of brick instead of stone for the lining work described in this Section, provided the proposed brick is sound and is not to be incorporated in any load-bearing structure.

2.2.1.2 Issue of Construction Details

Construction details of lined and unlined ditch works not included in the Contract Documents at the time of tender shall be issued by the Engineer after the Contractor has furnished the field survey report in accordance with Section 1.9 of these Specifications.

2.2.1.3 Related Work Specified Elsewhere

Related work includes but is not limited to the following:

- (a) Field Engineering : Section 1.9
- (b) Environmental Safeguards : Section 1.17
- (c) Ditches and Waterways : Section 2.1
- (d) Culverts and Concrete Drains : Section 2.3
- (e) Porous Drainage : Section 2.4
- (f) Concrete : Section 7.1
- (g) Stone Masonry : Section 7.9
- (h) Routine Maintenance of Pavements, Shoulders, Drainage, Road Furniture and Bridges : Section 10.1

2.2.1.4 Dimension Tolerances

- (a) The face surface of each facing stone shall not vary from the average surface profile of the surrounding stonework by more than 1 cm.
- (b) For ditch and waterway linings, the average surface profile formed by placed stonework shall not vary from the specified or approved channel invert profile by

more than 3 cm, nor from the specified or approved cross section profile by more than 5 cm.

- (c) The minimum thickness of any Mortared Stonework lining shall be 10 cm.
- (d) The finished profiles for minor, non-load bearing structures such as catch pits and spillway aprons shall not vary from the specified or approved profiles by more than 3 cm.

2.2.1.5 Submittals and Approvals

- (a) Prior to the intended date of first using any stone material proposed for use in Mortared Stonework, the Contractor shall submit to the Engineer two representative samples of 50 kg weight each of the stone. One of these samples shall be retained by the Engineer for reference throughout the Time for Completion. Only stone approved by the Engineer shall be used in the work.
- (b) No Mortared Stonework shall be commenced until the Engineer has approved the prepared formation for these Works.

2.2.1.6 Work Scheduling

- (a) The extent of Mortared Stonework carried out at any one time shall be limited in accordance with the rate of placing to ensure that all stones are placed only in fresh mortar.
- (b) Where Mortared Stonework lining is to be constructed on slopes or as ditch lining, the formation shall in the first instance be prepared as if there were no lining. The final shaping to the required lines shall only be made immediately prior to the placing of the stonework.

2.2.1.7 Work Site Conditions

The provisions specified in Article 3.1.1.7 of these Specifications regarding continuously maintaining a dry work site and ensuring that adequate sanitation facilities are available for the workmen, shall also apply for Mortared Stonework.

2.2.1.8 Rectification of Unsatisfactory or Failed Work

- (a) Mortared stonework which does not meet the tolerances given in Article 2.2.1.4 above shall be rectified by the Contractor at his own expense, in the manner directed by the Engineer.
- (b) The Contractor shall be responsible for the stability and integrity of all finished work and shall replace at his own expense any portions that become damaged or displaced due, in the opinion of the Engineer, to carelessness or neglect on the part of the Contractor. However, the Contractor shall not be held responsible for damage arising from such natural causes as storms or from unavoidable movement of the natural ground upon which the Work is placed, provided the works so damaged had previously been accepted in writing as satisfactory and complete by the Engineer.

2.2.1.9 Maintenance of Accepted Work

Notwithstanding the Contractor's obligation to carry out rectification of unsatisfactory or failed work as specified in Article 2.2.1.8 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted mortared stonework construction for drainage works throughout the remaining Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7.

2.2.2 MATERIALS

2.2.2.1 Stone

- (a) Stone shall consist of field stone or rough un hewn quarry stone which is sound, tough, durable, dense, resistant to the action of air and water, and suitable in all respects for the purpose intended.
- (b) Quality and dimension of stone shall be approved by the Engineer prior to use. Stone for lining ditches and waterways shall be as nearly rectangular in shape as is practical.
- (c) Unless otherwise provided by the Drawings or Specifications all stones used for Mortared Stone work shall be retained on a 100 mm sq aperture sieve.

2.2.2.2 Mortar

Mortar shall be Cement Mortar conforming to the requirements of Section 7.8 of these Specifications.

2.2.2.3 Porous Drainage

Materials for forming bedding, weep holes or filter pockets for Mortared Stonework shall conform to the requirements of Section 2.4 of these Specifications.

2.2.3 CONSTRUCTION OF MORTARED STONEWORK

2.2.3.1 Preparation of Formations or Foundations

- (a) Formations for Mortared Stonework lining shall be prepared in accordance with the provisions of Section 2.1 Ditches and Waterways.
- (b) Foundations or trenches for Mortared Stonework cut-off walls or Structures shall be prepared on accordance with the provisions of Section 3.1, Excavation.
- (c) Permeable bedding layers and filter pocket recesses shall be provided where specified in accordance with the provisions of Section 2.4, Porous Drainage.

2.2.3.2 Preparation of Stone

- (a) The stones shall be cleaned of all defects that may impair the bond with the mortar,

- (b) Prior to placement, stones shall be thoroughly wetted with ample time being allowed for the absorption of water to near saturation.

2.2.3.3 Placing Stone

- (a) A bedding of fresh mortar at least 3 cm thick shall be placed on the prepared formation. This mortar bedding shall be constructed progressively with the laying of surface stones in such a manner that the stones are always securely bedded in the mortar before it hardens.
- (b) The stones shall be firmly bedded one close against another to provide the required thickness of lining measured perpendicular to the slope. Mortar shall be placed to completely fill all spaces between the stones and shall be finished almost flush with the surface of the lining but not covering the stones.
- (c) The work shall be progressed from the bottom of slopes towards the top, and surfaces shall be finished immediately following the initial set of the mortar by sweeping with a stiff broom.
- (d) Finished surfaces shall be cured in accordance with Article 7.1.5.4 of these Specifications.
- (e) Adjacent slopes and shoulders shall be trimmed and finished to ensure a tight smooth interface with the Mortared Stonework that will allow unobstructed drainage and prevent scour at the edges of the work.

2.2.3.4 Construction Mortared Stonework Structures

- (a) Cut-off walls to be constructed in trenches, or other structures in which earth support or other formwork is provided, shall be constructed by filling the trench or forms with mortar to a depth of 60 percent of the maximum dimension of the stones and immediately thereafter placing stones in the unset mortar. Additional mortar shall than be added and the process repeated until the form is filled, Additional mortar shall than be added to the top so as to obtain a screened, level top surface.
- (b) If the stone shape is such that a sufficiently strong interlock can be obtained and if a stiff mortar is used, Mortared Stonework may also be constructed without forms, in the manner prescribed for Stone Masonry in Section 7.9 of these Specifications.
- (c) Exposed surfaces of Mortared Stonework structures shall be finished and cured as specified above for stone lining. Exposed top surfaces shall be finished with a 20 mm thick layer of mortar to the required lines and levels. The layer shall be returned round the tops of walls as directed by the Engineer.
- (d) Backfill around the finished, cured structure shall be placed in accordance with the provisions of Section 3.2, Fill, or Section 2.4, Porous Drainage.

2.2.4 MEASUREMENT AND PAYMENT

2.2.4.1 Measurement for Payment

- (a) Mortared stonework shall be measured for payment in cubic metres as the nominal volume of completed and accepted work.

- (b) For Mortared Stonework used for lining ditches and waterways, or lining any other surfaces, the nominal volume shall be defined by the area of the exposed surface of the finished work and the nominal thickness of the lining. For payment purposes, the nominal lining thickness shall be taken as the least of the following:
 - (i) The specified or approved thickness as shown on the Drawings or directed by the Engineer.
 - (ii) The average actual thickness placed as determined by field measurements.
- (c) For Mortared Stonework used in all other (non-lining) situations, the nominal volume for payment shall be calculated as the theoretical volume defined by the specified or approved lines and cross-sections.
- (d) Any materials placed in excess of the approved or theoretical volume shall not be measured or paid for.
- (e) Excavation for drainage ditches that are to be lined with mortared stonework shall be measured for payment in accordance with Section 2.1 of these Specifications.
- (f) Permeable bedding or granular filter pocket material shall be measured and paid under item Porous Drainage, as set out in Article 2.4.4 of these Specifications. No separate measurements or payment shall be made for the provision or installation of weep hole forms or pipes, nor for any other form work used.

2.2.4.2 Basis of Payment

The quantities of Mortared Stonework, determined as provided above, shall be paid for at the Contract Price per unit of measurement for the Pay Item listed below and shown in the Bill of Quantities, which price and payment shall be full compensation for furnishing and placing all materials, for all necessary formation of foundation preparation, for construction of weep holes, for dewatering the works, for backfilling and furnishing and for all other work or costs necessary or usual for the proper completion of the work prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
2.2	Mortared Stonework	Cubic Metre

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SECTION 2.3

CULVERTS AND CONCRETE DRAINS

2.3.1 GENERAL

2.3.1.1 Description

- (a) This work shall consist of the repair, extension, replacement or new construction of reinforced or un-reinforced concrete, or corrugated metal pipe culverts, box culverts, slab culverts, including head walls, inlet and outlet structures and associated scour protection works, all in accordance with the Drawings and these Specifications and at the locations indicated by the Engineer.
- (b) The work shall also include the installation of concrete lined drains, with cover slabs where required, at approved locations such as in urban areas and where water seeping from unlined ditches could contribute to embankment slope instability.

2.3.1.2 Issue Construction Details

Construction details of culvert and concrete drain works shall be as included in the Contract Documents or will be furnished by the Engineer.

2.3.1.3 Related Work Specified Elsewhere

Related works include but are not limited to the following:

- (a) Mobilization and Demobilization : Section 1.2
- (b) Traffic Management and Safety : Section 1.8
- (c) Field Engineering : Section 1.9
- (d) Environmental Safeguards : Section 1.17
- (e) Ditches and Waterways : Section 2.1
- (f) Mortared Stonework : Section 2.2
- (g) Porous Drainage : Section 2.4
- (h) Excavation : Section 3.1
- (i) Fill : Section 3.2
- (j) Concrete : Section 7.1
- (k) Cement Mortar : Section 7.8
- (l) Stone Masonry : Section 7.9
- (m) Daywork : Section 9.1
- (n) Routine Maintenance of Pavements, Shoulders,
Drainage, Road Furniture and Bridges : Section 10.1
- (o) Maintenance of Adjacent Roads and Bridges : Section 10.2

2.3.1.4 Reference Standard

Standar Nasional Indonesia (SNI) :

SNI 03-6719-2002 : Spesifikasi pipa baja bergelombang dengan lapis pelindung
(AASHTO M36 - 03) logam untuk pembuangan air dan drainase bawah tanah .

AASHTO :

AASHTO M170 - 07 : Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

2.3.1.5 Work Scheduling

- (a) No culvert or concrete drain work shall be commenced until the Engineers written approval has been issued.
- (b) As specified in Section 3.2 of these Specifications, satisfactory drainage must be in operation and effective before any excavation or filling work is undertaken. In most cases, this will require culvert work to be substantially completed before embankment work can be commenced, unless adequate drainage is otherwise ensured by special temporary works installed by the Contractor.
- (c) In accordance with the provisions of Article 3.3.1.6.(a) of these Specifications, no subgrade preparation or pavement overlay work, either in the carriageway or the shoulder areas, shall be commenced until the culverts, head walls and other minor structures below subgrade level along that section of the project have been completed.

2.3.1.6 Work Site Condition

The provisions given in Article 3.1.1.7, regarding site dewatering and maintaining on site sanitation, shall apply.

2.3.1.7 Rectification of Unsatisfactory Work

All work and materials for the construction of culverts and concrete drain shall conform to the dimensional tolerances and to the various provisions for rectifying unsatisfactory work that are given in the Sections of these Specifications relevant to the work or material concerned.

2.3.1.8 Maintenance of Accepted Work

Notwithstanding the Contractor's obligation to carry out rectification of unsatisfactory or failed work as specified in Article 2.3.1.7 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted culverts and concrete drains throughout the Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7.

2.3.1.9 Underground Utilities

The provisions specified for Excavation in Article 3.1.1.9 shall apply also to the work carried out under this Section.

2.3.1.10 Use and Disposal of Excavated Materials

The provisions specified for Excavation in Article 3.1.1.11 shall apply.

2.3.1.11 Site Restitution and Disposal of Temporary Works

The provisions specified for Excavation in Article 3.1.1.12 shall apply.

2.3.1.12 Control of Traffic

Traffic control shall conform with the provisions of Section 1.8, Traffic Management and Safety.

2.3.2 MATERIALS

2.3.2.1 Bedding

Granular material for bedding concrete drains, pipe culverts and other structures shall be in accordance with Section 2.4.

2.3.2.2 Concrete

Concrete used for all structural work described in this Section shall conform with the requirements specified in Section 7.1.

2.3.2.3 Reinforcing Steel for Concrete

All reinforcing steel used in the works shall conform with the requirements specified in Section 7.3.

2.3.2.4 Reinforced Concrete Culvert Pipes

Reinforced concrete culvert pipes shall be of precast reinforced concrete and shall conform with AASHTO specification M170 - 07.

2.3.2.5 Corrugated Metal Culvert Pipes

Corrugated metal culvert pipes shall be of zinc coated (galvanized) corrugated iron or steel and shall conform with SNI 03-6719-2002 (AASHTO M36 - 03).

2.3.2.6 Stone Masonry

Materials for mortared stone masonry headwalls and other structures shall conform with the provisions of Section 7.9.

2.3.2.7 Mortared Stonework

Materials for mortared stone lining, scour protection works and minor structures required for the works shall conform with the provisions of Section 2.2.

2.3.2.8 Mortar

Mortar for pipe joints and collars shall be Cement Mortar conforming with the requirements specified in Section 7.8. Unless tested in accordance with section 7.8 mortar shall be 1 part cement 3 part sand.

2.3.2.9 Filter Material

Filter materials used in the works shall conform with the requirements specified in Section 2.4.

2.3.2.10 Backfill

Fill material used in the works shall conform with the requirements specified in Section 3.2.

2.3.2.11 Blinding Stone

Blinding stone shall conform with section 7.9.2.1 (a) and shall have a thickness not greater than 15 cm and no less than 7,5 m.

2.3.3 EXECUTION

2.3.3.1 Site Preparation

- (a) Excavation and preparation of trenches and foundations for concrete drains and culverts shall be carried out in accordance with the provisions of Section 3.1, and in particular with those given in Article 3.1.2.3, Excavation for Structures and Pipes.
- (b) Bedding material shall be placed in accordance with the provisions of Section 2.4, and in particular with those given in Article 2.4.3.2, Placing Bedding Material.

2.3.3.2 Placement of Concrete Culvert Pipes

- (a) The concrete pipe shall be laid carefully, with hubs or grooved ends on the upper grade end, with spigot or tongued ends fully entered into the adjacent hub or groove, and placed true to the required lines and grades.
- (b) Before succeeding sections of concrete pipe are laid the lower half of the hub of the preceding section shall be plastered on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipes flush and even. At the same time the upper half of the spigot of the succeeding pipe shall be similarly plastered with mortar.
- (c) After the concrete pipe is laid, the remainder of the joint shall be filled with mortar, and sufficient additional mortar shall be used to form a bead around the joint.
- (a) Backfilling and compacting around and over concrete culvert pipes shall be carried out in accordance with Section 3.2, Fill, using material conforming to the requirements given for Selected Embankment. The material shall consist of soil or gravel which is free from clay lumps and vegetable matter and containing no stones that would be retained on 25 mm sieve.
- (d) The fill shall be taken to a minimum height of 30 centimetres above the top of the pipe and, unless in a trench, for a minimum distance of one and a half diameters from the center line of the pipe on either side. Special care shall be taken to ensure that the backfill under the haunches of the pipe is properly compacted.
- (e) Heavy earth moving and compacting equipment shall not operate closer to the culvert than 1.50 metres until it has been covered to a depth equal to at least 60 cm above the top of the pipes. Light weight equipment may be operated within the above limitation provided that backfill has been placed and compacted to give the minimum cover of 30 cm over the top of the pipe. Notwithstanding the above, the

Contractor shall be responsible for and shall make good any damage resulting from such operations.

- (f) Concrete pipes shall be surrounded with concrete, in accordance with the detail shown on the Drawings or as directed by the Engineer, when the depth of cover to be placed is more than the maximum or less than the minimum depths indicated on the Drawings or in the pipe manufacturer's specifications for the particular size and class of pipe.

2.3.3.3 Placement of Corrugated Metal Culvert Pipes

- (a) Corrugated metal pipe may be pre-assembled in sections at a designated work site or assembled in the prepared trench.
- (b) Pre-assembled corrugated metal pipe shall be lowered into its place with acceptable slings and shall not be excessively long so as to cause buckling at the joints. Care must be exercised to avoid damaging the ends and dropping the pipe during transportation or installation.
- (c) All assembled corrugated metal pipe shall be snugly bolted and the connecting bands toggled correctly so as to avoid excess strains.

2.3.3.4 Construction of Box and Slab Culverts

- (a) Box and slab culverts shall be constructed to the lines and dimensions given on the Drawings or as directed by the Engineer.
- (b) All reinforced concrete work shall conform to the requirements specified in Section 7.1, Concrete and Section 7.3, Reinforcing Steel.
- (c) All stone masonry work shall conform with the requirements of Section 7.9, Stone Masonry.
- (d) Box culverts may be cast in-situ or precast.

2.3.3.5 Culvert Head Walls and Inlet and Outlet Structures

- (a) Unless otherwise shown on the Drawings, spillway aprons and scour protection works associated with culvert work shall be constructed using Mortared Stone work as specified in Section 2.2. Generally, Mortared Stonework shall also be used for small culvert headwalls and other structures which are not to carry significant structural loads.
- (b) Head walls for large culverts or beneath high embankments, or other load bearing structures associated with culvert work, shall be constructed using Stone Masonry rather than Mortared Stonework, or, if loadings are sufficiently high, using Reinforced Concrete. The material to be used shall be as shown on the drawings or as directed by the Engineer, who shall take account of the quality and shape of the available stone for stone work and also the skill of the stone masons employed by the Contractor.

2.3.3.6 Extension to Existing Culverts

- (a) When the extension of an existing culvert requires the removal of an existing head wall, wing wall or other part, such parts shall be carefully demolished as specified in Section 7.15 in such a manner as to avoid damage to the pipes or structural elements which are to remain. If, in the opinion of the Engineer, unnecessary damage occurs to a part of a culvert designated to remain, the damaged part shall be replaced at the Contractor's expense.
- (b) Where existing and added culvert portions are of different design or, in the opinion of the Engineer, shall not permit a standard joint to be made, then a concrete collar shall be constructed to form the connection as shown on the Drawings or as directed by the Engineer.
- (c) All existing culverts, as well as culverts which are replaced, extended or newly installed under the Contract, shall be cleaned of all loose debris and dirt, and shall be maintained in a clean and operable condition throughout the Time for Completion.

2.3.3.7 Construction of Concrete Drains

- (a) Reinforced concrete drains and cover slabs shall be constructed in accordance with the lines, levels and other details shown in the Drawings, or as instructed by the Engineer, and in accordance with the provisions of Section 7.1, Concrete. The top of open U ditches or the top of cover slabs shall be constructed to a smooth profile, shall match the design level and the adjacent finished ground level, finished paved level or top of kerb, with a tolerance of ± 1 cm. Concrete drains may be cast in situ or pre-cast. Cover slabs shall be precast units and shall be removable.
- (b) For cast in-situ drains, the Engineer may permit the side of the excavation to be used in place of forms, in which case the thickness of wall and cover to the earth side reinforcement shall be increased by 25 millimetre without additional payment.
- (c) Weep holes shall be formed in the walls of the drains in accordance with the provisions of Article 2.4.3.5 and with the Drawings.
- (d) Construction joints in cast in-situ drains shall be formed at intervals of 10 metres or less. Such joints, as well as joints between butt jointed precast drain sections, shall be nominally 1 cm in width and shall be packed with mortar flush with the inside surface of the drains.

2.3.4 **MEASUREMENT AND PAYMENT**

2.3.4.1 Measurement for Payment

- (a) The quantity to be measured for payment for reinforced or un-reinforced concrete pipe culverts shall be the number of linear metre of new or extended pipe structure placed, measured from end to end of the pipes placed in accordance with the Drawings or with the Engineers instruction.
- (b) The quantity to be measured for payment for corrugated metal pipe culverts shall be the number of tonnes of new or extended pipe structure placed in accordance with the Drawings or with the Engineer instruction.

- (c) The quantity to be measured for payment for reinforced concrete U ditches up to 1200 mm width shall be the number of linear metres of cast in-place or pre-cast u ditch, measured from end to end and placed in accordance with the Drawings or with the Engineers instruction.
- (d) The quantity to be measured for payment for concrete headwalls, aprons, side entry pits, box culverts and other concrete drainage structures shall be the number of cubic metres of concrete and the number of kilograms of reinforcing steel placed in accordance with the Drawings or with the Engineers instruction.
- (e) Except for Rock Excavation and Porous Drainage material used, no separate measurement for payment shall be made for excavation or filling work, the cost of this work being deemed incidental to carrying out the culverts and included in the prices bid for the culvert piping and for the various construction materials used.

2.3.4.2 Basis for Payment

The quantities of Pipe Culvert, U ditches, box culverts and other minor concrete drainage structures, measured as provided above, shall be paid for at the Contract Price per unit of measurement respectively for each of the Pay Items listed below and shown on Bill of Quantities, which price and payments shall be full compensation for furnishing and placing all materials and for all excavation and disposal of materials, compaction, form work, backfilling, weep holes, and all other costs necessary or usual for the proper completion of the works prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
2.3.1	Reinforced Concrete Pipe Culvert Inside Diameter (nominal 40 cm) 35 - 45 cm	Linear Metre
2.3.2	Reinforced Concrete Pipe Culvert Inside Diameter (nominal 60 cm) 55 to 65 cm	Linear Metre
2.3.3	Reinforced Concrete Pipe Culvert Inside Diameter (nominal 80 cm) 75 to 85 cm	Linear Metre
2.3.4	Reinforced Concrete Pipe Culvert Inside Diameter (nominal 100 cm) 95 to 105 cm	Linear Metre
2.3.5	Corrugated Steel Culvert	Tonne
2.3.6	Un-reinforced Concrete Pipe Culvert Inside Diameter 20 cm	Linear Metre
2.3.7	Un-reinforced Concrete Pipe Culvert Inside Diameter 25 cm	Linear Metre
2.3.8	Un-reinforced Concrete Pipe Culvert Inside Diameter 30 cm	Linear Metre

2.3.9.1	U Ditch Type DS 1	Linear Metre
2.3.9. 1a	U Ditch Type DS 1A	Linear Metre
2.3.9. 2	U Ditch Type DS 2	Linear Metre
2.3.9. 2a	U Ditch Type DS 2a	Linear Metre
2.3.9.3	U Ditch Type DS 3	Linear Metre
2.3.9.3a	U Ditch Type DS 3a	Linear Metre
2.3.9.4	U Ditch Type DS 4	Linear Metre
2.3.9.4a	U Ditch Type DS 4a	Linear Metre
2.3.9.5	U Ditch Type DS 5	Linear Metre
2.3.9.5a	U Ditch Type DS 5a	Linear Metre
2.3.9.6a	U Ditch Type VI	Linear Metre
2.3.10	Concrete Class K 250 for minor concrete drainage structures	Cubic Metre
2.3.11	Reinforcing steel for minor concrete drainage structures	Kilograms
2.3.12	Blinding stone for minor concrete drainage structures	Cubic metres

SECTION 2.4

POROUS DRAINAGE

2.4.1 GENERAL

2.4.1.1 Description

- (a) This work shall consist of winning, hauling, placing and compacting porous drainage materials required for the bedding of concrete drains or pipes or for subsurface drainage purposes or to prevent the washout or scour of soil fines by groundwater seepage. The work also includes the supply and placing of porous pipes (drain type) and soil filter fabrics where these materials are called for.
- (b) These materials are to be used against the rear faces of abutments, wing walls retaining walls, rip rap and gabion walls, and in the construction of pavement subsurface drains, concrete lined drains, culverts, sand blankets and chimney drain, for stabilization works, weep hole pockets, slope toe filters and other similar works, in accordance with these Specifications or as directed by the Engineer.

2.4.1.2 Issue of Construction Details

Construction details for Porous Drainage not included in the Contract Documents at the time of tender shall be furnished by the Engineer after initial design review or design revision has been completed in accordance with Section 1.9 of these Specifications.

2.4.1.3 Related Work Specified Elsewhere

Related works specified elsewhere may include but shall not be limited to the following:

- (a) Field Engineering : Section 1.9
- (b) Environmental Safeguards : Section 1.17
- (c) Mortared Stonework : Section 2.2
- (d) Culverts and Concrete Drains : Section 2.3
- (e) Excavation : Section 3.1
- (f) Fill : Section 3.2
- (g) Concrete : Section 7.1
- (h) Cement Mortar : Section 7.8
- (i) Stone Masonry : Section 7.9
- (j) Rip-rap and Gabions : Section 7.10

2.4.1.4 Dimensional Tolerances

- (a) Finished profiles for porous drainage granular fill shall not vary from the specified or approved profiles by more than 2 cm.
- (b) Finished levels and grades for pipe and concrete drain bedding material shall not vary from those specified or approved by more than 1 cm.
- (c) Dimensional tolerances for the shape, diameter, and length and wall thickness of porous pipes shall be as specified in AASHTO 178M/ M178 - 07. The maximum gap between the ends of butt jointed porous pipes when laid shall be 5 mm.
- (d) The minimum fall in drains constructed using porous pipe, shall be 1 : 1000.

- (e) Foundation surfaces for porous drainage used in drainage blankets shall be smooth and regular with a uniform fall that shall prevent ponding. The minimum grade for such surfaces shall be 1 : 200.

2.4.1.5 Reference Standards

Standar Nasional Indonesia (SNI) :

SNI 03-4142-1996 (AASHTO T11 - 05)	:	Metode Pengujian Tentang Analisa Saringan Agregat Halus dan Kasar.
SNI 03-1968-1990 (AASHTO T27 - 06)	:	Metode Pengujian Tentang Analisa Saringan Agregat Halus dan Kasar.
SNI 03-3422-1994 (AASHTO T88 - 00 (2004))	:	Cara Uji Analisis Ukuran Butir Tanah.
SNI 03-1967-1990 (AASHTO T89 - 02)	:	Cara Uji Penentuan Batas Cair untuk Tanah.
SNI 03-1966-1990 (AASHTO T90 - 00)	:	Cara Uji Penentuan Batas Plastis dan Indeks Plastisitas Tanah.
SNI 03-1742-1989 (AASHTO T 99 - 01 (2004))	:	Cara Uji Kepadatan Ringan untuk Tanah.
SNI 03-2828-1992 (AASHTO T191 - 02 (2006))	:	Metode Pengujian Kepadatan Lapangan dengan Alat Konus Pasir.

AASHTO :

AASHTO 178M/ M178 - 07	:	Concrete Drain Tile
AASHTO 252 - 07	:	Corrugated Polyethylene Drainage Pipe
AASHTO 278 - 02	:	Class PS46 Poly (Vinyl Chloride) (PVC) Pipe

2.4.1.6 Submittals

- (a) At least 21 days prior to the proposed date of placing any materials, representative samples shall be submitted to the Engineer.
- (b) In the case of porous drainage or filter material, at least one 50 kg sample of each material proposed to be used shall be submitted together with 5 kg samples of the materials that will be upstream and downstream of water seeping through the porous drainage. The results of wash grading tests (SNI 03-1968-1990) shall also be supplied for each sample submitted.
- (c) Samples of porous pipe or filter mesh proposed to be used shall be submitted together with the manufacturer's specifications and proof-test data.
- (d) The Contractor shall notify the Engineer in writing when the placing is complete and before the work is concealed by any other material or work. The notification of completion shall be accompanied by the results of density tests as specified in Article 2.4.3.1.(c) and by survey records verifying that the dimensional tolerances given in Article 2.4.1.4 are met.

2.4.1.7 Work Scheduling

- (a) Clean granular porous drainage material must be placed only immediately prior to the placing of the overlaying materials.

- (b) Granular Porous Drainage material in vertical slot drains in new embankment shall be placed in horizontal layers at the same time as the other embankment fill layers are laid.

2.4.2 MATERIALS

2.4.2.1 Porous Drainage or Filter Material

- (a) Granular porous drainage or filter material shall be hard, durable and clean. It shall be free from organic material, clay balls and other deleterious substances, laterite or concretionary materials shall not be used.
- (b) The required particle grading of the material will depend on its intended function in the works and on the characteristics in the materials that will be upstream and downstream of water seeping through it, and also on the materials available. The grading required in each case shall be as directed by the Engineer, whose assessment shall include ensuring that “Piping” (washing-out of fines) cannot occur from the upstream material into the porous backfill or from the porous backfill into the downstream material, in accordance with the following criteria :

(i)
$$\frac{D_{15} \text{ (filter)}}{D_{85} \text{ (soil)}} < 5$$

(ii)
$$4 < \frac{D_{15} \text{ (filter)}}{D_{15} \text{ (soil)}} < 20$$

(iii)
$$\frac{D_{50} \text{ (filter)}}{D_{50} \text{ (soil)}} < 25$$

where D_{15} , D_{50} and D_{85} are the particle sizes from the grading curve at 15 %, 50 % and 85 %, respectively, finer by weight. The term “filter” refers to the coarser protecting material; the term “soil” refers to the finer material being protected from piping.

- (c) Grading envelopes for porous backfill and filter materials which would carry seepage water without piping from typical embankment clay to 30 cm diameter rip rap are illustrated on the Drawings Sheet titled “Selection of Porous Drainage Material” in these Contract Documents. The figure, which shows generally that the rip rap must be protected by a gravel, the gravel by a sand and the sand by a fine silty sand or plastic filter mesh, is given for general guidance only and shall not necessarily be used as a basis on which to approve or reject materials.
- (d) In the case where there is no granular material downstream of the porous drainage material but rather weep holes or pipe perforations, selection and approval of the porous drainage material shall be based on the following criteria:
 - (i) $D_{85} \text{ (backfill)} > 0.2 \times D \text{ (hole)}$
 - and
 - (ii) $D_{50} \text{ (backfill)} > 0.04 \times D \text{ (hole)}$

where D_{85} and D_{50} are as defined in this Article in (b) above and D (hole) is the inside diameter of the weep hole or pipe perforation.

- (e) Any sized porous drainage may be safely used downstream of a plastic filter mesh. For example, in the case of pavement subsurface drains, the porous backfill may be coarse uniform cobbles if the trench sides are protected with the suitable plastic filter mesh, but generally must be a fine sand, if there is no plastic filter mesh. Under no circumstances shall coconut palm fibre (ijuk) be used as a substitute for a specified plastic mesh.

2.4.2.2 Bedding Material for Pipes and Concrete Drains

Granular material for use as bedding material shall be sand, sandy gravel or crushed rock and shall conform with the following requirements.

- (i) Maximum Particle Size : 20 mm or less, but at least twice the maximum clear gap in any open jointed pipe
(SNI 03-3422-1994)
- (ii) Passing No. 200 Sieve : 15% maximum
(SNI 03-4142-1996)
- (iii) Plasticity Index : 6 maximum
(SNI 03-1966-1990)
- (iv) Liquid Limit : 25 maximum
(SNI 03-1967-1990)

The material shall be well graded rather than uniform.

2.4.2.3 Plastic Filter Mesh

Plastic filter mesh shall be a propriety woven synthetic geotextile fabric approved by the Engineer. Selection of the mesh opening size (MOS) for filter fabric shall be based on the particle size distribution curve for the soil upstream of the filter fabric in accordance with whichever is the smaller of:

- (i) $D_{85}(\text{backfill}) > 5 \times D_{85}(\text{soil})$

and

- (ii) $D_{50}(\text{backfill}) > 25 \times D_{50}(\text{soil})$

where, D_{85} and D_{50} are as defined in Article 2.4.2.1.(b) above.

2.4.2.4 Porous Pipes and Weep Hole Pipes

- (a) Porous pipes for subsurface drainage shall be porous concrete, perforated PVC, or corrugated perforated polyethylene drain type of approximately 100 mm inside diameter and meeting the requirements specified by AASHTO M176M/ M176-07, M252-07, M278-02 or other specification approved by the Engineer.
- (b) Pipes to be placed through concrete or mortared walls or linings as weep holes shall be 50 mm inside diameter and shall be PVC or any material approved by the Engineer which is strong enough to resist being deformed during construction and setting of the mortar or concrete.

2.4.2.5 Mortar

Mortar used for locking pipe joints shall be Cement Mortar in accordance with Section 7.8 of these Specifications.

2.4.3 **PLACING POROUS DRAINAGE MATERIAL**

2.4.3.1 Placing Porous Drainage Material

- (a) Before Porous Backfill shall be placed on any area, all unsuitable too soft or too hard material shall have been replaced in accordance with Article 3.1.1.11 and 3.1.2.1 of these Specifications.
- (b) Placing of Porous Backfill around pipes or drains or behind structures shall be performed systematically and as soon as possible following placing of the pipes or structure. A minimum period of 14 days before backfilling, however, should be allowed following the mortaring of pipe joints or the placing of structures.
- (c) The Porous Backfill shall be thoroughly compacted in layers not exceeding 15 cm compacted thickness to a density in excess of 95 % of the maximum dry density determined according to SNI 03-1742-1989. Any approved method of compaction may be used which achieves the required density.
- (d) The adequacy of compaction shall be monitored by density tests in accordance with SNI 03-2828-1992, and if the tests show insufficient density has been obtained the Contractor shall apply additional compaction or otherwise remedy the work as directed by the Engineer. The frequency and position of testing shall as directed by the Engineer.
- (e) Thin drainage blankets (less than 20 cm thick) of Porous Backfill which are to be covered with earth fill shall be only nominally compacted before the first layer of earth fill is placed on top. The earth fill layer shall then be heavily compact until the underlying layer of Porous Backfill has attained the specified density.
- (f) Until it is covered by other materials, Porous Drainage material shall be careful protected from disturbance by traffic or feet. Temporary wooden planks shall laid over sand blankets to allow the passage of workmen and the first layer of over the porous material shall be carefully spread by hand methods to avoid co-mingling of the two materials.
- (g) Care shall be taken to ensure minimum contamination of the Porous Backfill material with the adjacent soil or fill, and where, in the opinion of the Engineer this is occurring, or is likely to occur, a form shall be used to separate the two materials during placing. The form shall be 3 mm thick steel sheet or similar and shall be gradually lifted as the backfilling work proceeds. The form shall completely removed from the completed fill.

2.4.3.2 Placing Bedding Material

- (a) Trenches or foundation pits for pipe culverts, concrete drains, subsurface drains or other works requiring a bedding layer shall be excavated in accordance with Section 3.1 of these Specifications and a firm bed of uniform compaction prepared to the required grade less the required thickness of bedding material.

- (b) The thickness of the bedding for pipes shall be not less than 10 % of the diameter of the pipe nor less than 50 mm for any works.
- (c) Pipe bedding shall be shaped (using a semi-circular template of the same diameter as outside diameter of the pipe) to fit the underside of the pipe, so that it provides uniform support. When bell and spigot pipe is used, recesses shall also be dug to accommodate the bells.

2.4.3.3 Placing Plastic Filter Mesh

Plastic filter mesh shall be installed in accordance with the procedures recommended by the manufacturer and as directed by the Engineer.

2.4.3.4 Placing Porous Pipes

- (a) Beds for porous pipes shall be prepared as above but using Porous Backfill as specified in Article 2.4.2.1 rather than Bedding Material as specified in Article 2.4.2.2.
- (b) The porous pipes shall be placed on the prepared bed and carefully positioned with respect to both alignment and grade. Concrete pipes shall be butt jointed with a 1 to 5 mm gap left between pipes. The joints shall be wrapped with an approved filter fabric which shall allow passage of water but not the porous backfill material. The upper half of each joint shall be further protected with a strip of tarred paper or similar non-perishable sheeting material. Each joint shall be locked in place, but not sealed, using a small amount of cement mortar on either side.
- (c) After the pipes have been laid, inspected and approved, porous backfill material shall be placed and compacted as specified in Article 2.4.3.1 above.

2.4.3.5 Construction of Weep holes

- (a) Where weep holes are required to be formed through a wall or other construction without the permanent incorporation in the works of a pipe or other forms the method of forming the weep holes shall be subject to the approval of the Engineer.
- (b) All non-durable forms shall be removed on completion of the structure.
- (c) Weep holes shall be formed horizontally unless otherwise directed by the Engineer.
- (d) Pipes that are to be encased in concrete as weep holes, or as forms for weep holes, shall be held or braced rigidly during the concrete placement.
- (e) Unless otherwise specified or directed by the Engineer, weep holes shall be spaced horizontally and vertically at intervals no greater than 2 metres and 1 metre respectively.
- (f) Where filter pockets are required to be formed at the back of weep holes the filter material shall extend into the bedding or backfill for a distance of at least 30 centimetres from the end of the hole in all directions, unless otherwise specified or directed by the Engineer.

2.4.4 MEASUREMENT AND PAYMENT

2.4.4.1 Measurement of Porous Drainage Material or Filter Material

- (a) Fill shall only be classified and measured as Porous Backfill or Filter Material when used in locations or for purposes where Porous Backfill or Bedding or Filter Material of Filter Pockets or Drainage Blanket have been specified or otherwise approved in writing by the Engineer, and when the material has been accepted by the Engineer as being suitable as Porous Drainage in terms of the relevant provisions of this Section.
- (b) The quantity of Porous Backfill to be measured for payment shall be the number of cubic metres of the compacted material required to fill the specified or approved lines. Any material placed in excess of the approved theoretical volume shall be regarded as either Common Fill or Selected Fill, as directed by the Engineer, and shall not be measured under this section irrespective of its material qualities.
- (c) All approved porous backfill used and accepted on the Contract, and which qualifies for measurement as above, shall be measured and paid for under this Section.

2.4.4.2 Measurement of Plastic Filter Mesh

The quantity of Plastic Filter Mesh to be measured for payment shall be the number of square metres of approved fabric actually installed in the works and accepted in place.

2.4.4.3 Measurement of Porous Pipes

The quantity of Porous Pipe to be measured for payment shall be the number of linear metres of approved pipe actually installed in the works and accepted in place. No deduction in the measured length shall be made for the gaps at the pipe joints so long as the joints are formed as required by these specifications.

2.4.4.4 Weep Holes, Tarred Paper and Cement Mortar

Pipe used for forming weep holes, tarred paper or other sheeting used to wrap pipes and cement mortar used to seal joints between the pipe shall not be measured for payment, the cost of these materials being deemed to be included in the bid price for Subsurface Drainage Works.

2.4.4.5 Excavation for Porous Drainage Material, Filter Material

Except for Rock Excavation, no separate measurement for payment shall be made for excavation for filling work, the cost of this work being deemed incidental to carry out the Porous Backfill or Filter Material and included in the prices bid for the various construction materials used.

2.4.4.6 Excavation for Subsurface Drainage Works

The quantity of excavation for Subsurface Drainage Works shall be measured for payment in accordance with Section 3.1, Fill.

2.4.4.7 Basis of Payment

The work measured as provided above shall be paid for at the Contract Unit Price for the Pay Items listed below and included in the Bill of Quantities, which prices and payment

shall be full compensation for all labor, material, equipment and incidentals required to complete satisfactorily the work prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
2.4.1	Porous Drainage or Filter Material	Cubic Metre
2.4.2	Plastic Filter Fabric	Square Metre
2.4.3	Perforated or porous Pipe for Subsurface Drainage Works.	Linear Metre