

**MOKOLO AND CROCODILE
WATER AUGMENTATION PROJECT
PHASE 2 (MCWAP-2)**

TENDER NO 054/2024/PMID/MCWAP2/RFB

**PART C3.1
SPECIFICATION**

SECTION 15

BACKFILLING AND BEDDING

PART C3.1 SPECIFICATION

SECTION 15 BACKFILLING AND BEDDING

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SECTION 15

BACKFILLING AND BEDDING

15.1 SCOPE

This Section covers:

- a) Bedding and backfilling of trenches and service crossings for all types and sizes of pipes, culverts, site services and electrical conductors. It covers the preparation of a trench bottom, supply, placing and compaction of bedding, backfilling and the reinstatement of surfaces. In the following Clauses references to trenches shall also apply mutatis mutandis to pits and reference to pipes shall also apply mutatis mutandis to conduits, culverts and cables; and
- b) General earthworks, backfilling around all types of structures, the construction of platforms and terracing.

This Section shall be read in conjunction with Section 9 - Bulk Surface Excavations and Trenching and Section 14 - Spoil, Borrow and Excavated Materials. Section 16 covers embankment construction which includes embankment dams.

15.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

15.2.1 Definitions

For the purposes of this Section the following definitions shall apply:

- a) **“Bed”** means the zone in which bedding is placed and compacted over the full width of the trench, to a minimum depth of 200 mm or as specified by the Engineer, on which a pipe or duct is placed such that the pipe is uniformly supported over the entire length of the pipe.
- b) **“Bedding cradle”** means the zone above the Bed in which bedding is placed firmly without voids under and up both sides of a pipe or duct such that the pipe is uniformly supported over an arc length of 120°, up to the underside of the Selected Fill Blanket.
- c) **“Selected fill blanket”** means the zone above the Bedding Cradle in which material is placed and compacted to form a blanket around the pipe on or from the top of the Bedding Cradle up the sides and 300 mm over the top of a pipe, duct, or cable, in such a manner that the barrel of the pipe, duct, or cable is supported continuously and protected over the top by a dense cushion of Fill Blanket material.
- d) **“Bedding material”** means the material placed in the Bed, Bedding Cradle or Selected Fill Blanket.
- e) **“Main backfill”** means the approved filling material placed and compacted in the pipe trench after the pipe has been laid, bedded and surrounded by the completed Selected Fill Blanket.
- f) **“Flexible pipe”** means a pipe of which the diameter is reduced by more than 1% under an external radial force before the appearance of cracks.
- g) **“Joint hole or Fox hole”** means a depression formed in the bed and trench bottom to accommodate a joint or pipe stiffeners in a pipeline. The Joint Hole shall be large enough to allow adequate working space to perform welding of the pipe joint and to apply (and repair if necessary) the corrosion protection of the pipe over the welded pipe joint section.

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- h) **“Rigid pipe”** means a pipe, the diameter of which is reduced by not more than 1% under an external radial force before the appearance of cracks.
- i) **“Payment line”** means the Employer defined line applicable for measurement and payment for backfilling of the excavation required for the Permanent Works. The payment line is vertical to the underside of the pipe bed or structure base. For pipe chambers and other structures, the vertical payment line is 1 m from the outside of the walls at the base and the horizontal payment line is the underside of the concrete blinding layer to the levels indicated on the drawings. This definition shall be the default approach unless indicated otherwise on the drawings.
- j) **“Excavation profile”** is the initial assumed excavation profile at design and tender stage, interpreting and taking account of the available data regarding the prevailing geotechnical conditions.

The purpose of this assumed excavation profile at design and tender stage is to:

- Perform a realistic and comparative mass balance calculation;
- Check construction production rates;
- Check excavation price adjustment for use of vertical payment lines; and
- Check constructability from an available working space and safety allowance perspective.

The Contractor shall be responsible for all lateral support and the safe-guarding of all excavations, and all costs involved with the proper safeguarding of the excavations and this shall be included in the tendered rates.

The final actual constructed excavation quantities shall be determined from the monthly drone based laser terrestrial survey process. The re-measurable variables associated with the excavation profile are:

- Natural ground level to be agreed at the start of construction;
- Final trench length;
- Agreed final rock line/hard excavation line; and
- Any formal instruction issued by the Engineer that changes dimensions, lines or levels.

- k) **“Compaction moisture content”** means the range of moisture content between –1% and +2% of the optimum moisture content determined for the respective soil samples.
- l) **“Soilcrete”** means a flowable mixture of soil, cement and water that is used as a bedding cradle to provide uniform support to the pipe and achieve a minimum compressive strength of 200 kPa at 7 days and a minimum compressive strength of 700 kPa at 28 days. It can also be used for other specific backfilling applications as directed by the Engineer. The strengths required for each application shall be agreed with the Engineer.
- m) **“Embankment”** means an earthworks structure constructed using Fill.
- n) **“Foundation for embankment (or terrace)”** means the natural in-situ material on which the Embankment (or Terrace) is to be constructed.
- o) **“Fill”** means the earthworks constructed on the Foundation for Embankment (or Terrace) for the construction of earthworks, an Embankment or Terrace.
- p) **“Selected fill”** means the upper layer or layers of the Embankment or Terrace (also referred to as **Selected layers**) which are controlled both in quality and density by requirements more stringent than those for Embankments (or Terraces) in general.
- q) **“Structure backfill”** means the approved material placed and compacted against structures as backfilling or fill.

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- r) **“Roller passes”** An area will be taken to have received one roller pass when a roller has passed over such an area once. Additional passes made only as a result of overlapping so as to ensure full coverage shall not be taken into account.
- s) **“California bearing ratio”** The California Bearing Ratio (CBR) of an untreated soil or gravel as determined by means of Method A8 of TMH1 is the load in Newtons, expressed as a percentage of California standard values, required to allow a circular piston of 1 935 mm² to penetrate the surface of a compacted material at a rate of 1.27 mm per minute to depths of 2.54, 5.08 and 7.62 mm. The California standard values for these depths are 13.344, 20.016 and 25.354 kN respectively.
- t) **“Layer thickness”** means the specified thickness of a layer after compaction has been completed.

15.2.2 Abbreviations

AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society for Testing Materials
BS	:	British Standard
CBR	:	Californian Bearing Ratio
CEM	:	Calcium Enriched Mixture (Cement)
COLTO	:	Committee of Land Transport Officials
CSIR	:	Council for Scientific and Industrial Research
EN	:	European Norm
GM	:	Grading Modulus
LL	:	Liquid Limit
LS	:	Linear Shrinkage
MDD	:	Maximum Dry Density
OMC	:	Optimum Moisture Content
PI	:	Plasticity Index
PMB	:	Polymer Modified Bitumen
SANS	:	South African National Standard
TMH	:	Technical Methods for Highways
TW	:	Tape Wrapping

15.2.3 References

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

15.3 MATERIALS

15.3.1 Classes of Excavation

The excavation of material will, for purposes of measurement and payment, be classified as specified in Clause 9.4 of Section 9 – Bulk Surface Excavations and Trenching.

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15.3.2 Bedding Material

Bedding Material for flexible pipes shall be material complying with the criteria in Table 15/1.

**TABLE 15/1
BEDDING MATERIAL TYPE**

BEDDING MATERIAL TYPE	BEDDING ZONE (Note 1)	USC CLASSIFICATION	ADDITIONAL REQUIREMENTS (Note 3)	SOIL DESCRIPTION
SC1	Bed, Bedding Cradle, Selected Fill Blanket	SW, SP, GW, GP or any soil type beginning with one of these symbols	5% to 12% passing the No. 200 sieve (0.075 mm). Plasticity Index (PI) of whole sample to be Non-Plastic (NP)	Clean coarse- grained soils
SC2	Bed, Bedding Cradle, Selected Fill Blanket	GM, GC, SM, SC or any soil type beginning with one of these symbols	12% to 50% passing the No. 200 sieve (0.075 mm). PI (whole sample) to be less than 12.	Coarse grained soils with fines

Notes:

1. Refer to the Drawings for the definition of bedding zones referred to in Table 15/1.
2. The maximum particle size for all material types shall be 9.5 mm, except for Polymer Modified Bitumen (PMB - e.g. Bituguard) or Tape Wrapping (TW) pipe coatings where the maximum particle size for all material types shall be 3.0 mm. This requirement is applicable to all buried pipe sections (pipes, pipe specials and fittings, pipe joints etc.) with PMB or TW coating.
3. The use of A-3 and A-2-4 material (based on AASHTO Classification) shall be subject to the Engineer's approval and it shall be compacted at Optimum Moisture Content (OMC) plus 2% or minus 1%. It shall not be placed and worked in wet conditions nor be allowed to become saturated before it has been placed in position and compacted. If the material has dried out before it is covered, the top surface could break down during activities on the surface and the material shall then be reworked to achieve the specified density.
4. All material to be free of vegetation and other organic material to a standard acceptable to the Engineer.

15.3.3 Main Backfill Material

Material excavated from trenches shall be used as Main Backfill in all areas, provided it contains little or no organic material, it excludes boulders of dimension exceeding 150 mm and can be placed without significant voids and compacted as to avoid significant settlement.

In areas subject to loads from road traffic and in other areas as directed by the Engineer, Main Backfill shall have a PI not exceeding 12 and a minimum CBR of 15% at specified density if the backfill is to be placed in the upper 150 mm of the road subgrade and a PI not exceeding 12 and a minimum CBR of 7% if the backfill is to be placed lower in the road subgrade.

15.3.4 Soilcrete for Pipe Bedding

Soil for soilcrete shall be selected from the trench excavations or, if no suitable soil is available from that source, imported from a borrow area. The material shall be a fine, sandy or clayey-sand soil

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with a plasticity index of not more than 10 and shall comply with the grading requirements in Table 15/2.

**TABLE 15/2
SOILCRETE MATERIAL TYPE**

SCREEN SIZE (mm)	PERCENTAGE BY MASS PASSING SCREEN
9,50	100
0,075	<25

Note:

Maximum particle size for all material types is 9.5 mm, except for Polymer Modified Bitumen (PMB - e.g. Bituguard) or Tape Wrapping (TW) pipe coatings where the maximum particle size for all material types is 3.0 mm. This requirement is applicable to all buried pipe sections (pipes, pipe specials and fittings, pipe joints etc.) with PMB or TW coating.

Cement for soilcrete shall be Portland cement CEM I 42,5, 42,5R or 52,5 or a combination of these cements which shall comply with the latest requirements of SANS EN 197-1. Cement shall be delivered to the Site in a dry condition undamaged by exposure to the weather and shall be stored on the Site in approved weather and damp-proof conditions.

The soilcrete shall be designed to produce a flowable mix that will flow freely into the trench or formwork and under the pipe without segregation and which, in addition, will attain the specified compressive strengths and have low drying shrinkage.

The proportions of soil, cement and water shall be based upon laboratory tests made with the soil, cement and water to be used on the work. The Contractor shall timeously submit a detailed report of the proposed soilcrete mix design to the Engineer for his approval before the work begins. This report shall show that the mix complies with the Specification and shall give for at least three different water contents, the flow consistency, 7-day and 28-day compressive strengths and the drying shrinkage. It is envisaged that the cement contents will vary between 4% to 5% of the mix, by mass.

The flow consistency of the mix shall be tested in accordance with the requirements of the latest edition of ASTM D6103-17. A guide flow consistency for the laboratory mix is a spread diameter of 200 mm. Based on the laboratory report and field trials the Engineer will specify a suitable range of flow consistency. The site mix shall be sampled and tested by the Contractor prior to and at the point of placement in the trench. Any batch not complying with the Specification shall be removed from Site or disposed of.

The compressive strength shall be determined from 150 mm cubes sampled at the point of placement. The Contractor shall sample a minimum of 6 cubes per placement lift. After filling the cube moulds with the soilcrete mix, the top surface shall be sealed with a non-porous plate. Once the initial set has taken place the top plate shall be removed and the filled cube mould placed in a sealed plastic bag and stored on Site between 20°C to 25°C until required for testing. Testing shall take place at a laboratory to be approved by the Engineer. The testing machine and test method shall comply with the latest requirements of ASTM D4832-16 Ed. The soilcrete compressive strength shall be a minimum of 200 kPa at 7 days and a maximum of 700 kPa at 28 days.

The drying shrinkage shall be determined from samples prepared using the 280 mm x 50 mm x 50 mm moulds specified in the latest edition of SANS method 836. Soilcrete samples of the required flow consistency shall be oven-dried to constant mass and the linear shrinkage of each sample

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reported to the nearest 0.1%. The site mix shall be sampled by the Contractor prior to and at the point of placement in the trench. A minimum of 6 samples per placement lift shall be collected and tested in an approved laboratory.

All soilcrete shall be batched and mixed under the supervision of a competent and experienced person. The quantity of water used in each batch of soilcrete shall be carefully adjusted to maintain the required flow consistency for the approved mix. Allowance shall be made for the moisture content of the soil which shall be determined either by weighing and drying or other approved methods. All soilcrete shall be thoroughly mixed and the whole of each batch shall be uniform, free of lumps and free from segregation.

Soilcrete shall be transported to and placed in the trench using suitable equipment to avoid segregation, and to ensure proper flow underneath the pipe. The Contractor shall take all necessary precautions, to be approved by the Engineer, to avoid pipe floatation such as placing the soilcrete fill in more than one layer.

15.3.5 Fill

Fill material for general earthworks, embankments and terracing shall be natural material (soil, sand or gravel) and conform to the requirements specified below:

- a) The completed Fill shall contain no rocks or stones greater than two thirds of the layer thickness;
- b) Hard or rock material shall have a maximum dimension of 300 mm;
- c) Maximum Plasticity Index shall be 18; and
- d) Minimum California Bearing Ratio (CBR) at specified in-situ density:
 - Depth below top of fill, 0 m to 1.2 m Minimum 3% at 90% of Modified AASHTO
 - Depth below top of fill, 1.2 m to 9 m Minimum 3% at 100% of Modified AASHTO

By an order in writing the Engineer may allow the use of material not meeting these requirements, provided he has satisfied himself regarding the stability of the Embankment to be built from such material and provided further that the minimum CBR of the material at 100% modified AASHTO density exceeds 3%. The requirements for Fill material in the lower layers of Embankments higher than 9 m, shall be given by the Engineer.

15.3.6 Selected Fill

Selected Fill material for general earthworks, embankments and terracing shall be natural material (soil, sand or gravel) and conform to the requirements specified below:

- a) The completed Selected Fill shall contain no rocks or stones greater than two thirds of the layer thickness;
- b) Hard or rock material shall have a maximum dimension of 300 mm;
- c) Minimum CBR at 93% Modified AASHTO maximum dry density shall be at least 15%;
- d) Maximum Plasticity Index of 12, unless otherwise instructed by the Engineer (the Engineer shall have the right to alter the latter requirement to 3 times grading modulus +10);
- e) Minimum grading modulus of 0.75 and maximum grading modulus of 2.7; and
- f) Maximum swell of 1.5% at 100% Modified AASHTO density.

In-situ material falling within the Selected Fill horizon shall, when not conforming to the requirements for Selected Fill material, be excavated and replaced with Selected Fill material.

15.3.7 Structure Backfill

Material placed as backfill or as fill against structures shall comply with the requirements of Fill materials (see Clause 15.3.5), except that backfill within 1 000 mm of structures shall not contain more than 10% rock or hard fragments retained on a sieve of nominal aperture size of 50 mm and shall have a maximum dimension of 100 mm.

15.3.8 Selection of Material

15.3.8.1 General

The Contractor shall not dispose of excavated material suitable for re-use unless it is surplus to the requirements of the Contract.

The Contractor shall excavate and stockpile material (as required to suit the Contractor's approved methods of working) in such a way that material suitable for re-use are kept separate. He shall take positive steps to avoid burying or contaminating materials which otherwise would be suitable for re-use

When material otherwise suitable for re-use from excavations is contaminated, the Contractor shall, to make up any shortfall, obtain (at his own expense if the contamination is due to his actions) suitable material from other excavations on the Site, or by opening up borrow pits, or by importing from commercial or other sources.

Stockpiled materials shall be arranged so as to not obstruct the Works, traffic or drainage. Surplus material not required for re-use and re-instatement shall be removed to designated spoil dumps during the progress of the work.

15.3.8.2 Pipelines

The Contractor shall not dispose of excavated material that complies with the requirements for Bedding Material and Main Backfill unless it is surplus to the requirements of the Contract.

The Contractor shall excavate and stockpile material (as required to suit the Contractor's approved methods of working) in such a way that the various constituents for use as topsoil, fertile soil, Bedding Material and Main Backfill are kept separate. He shall take positive steps to avoid burying or contaminating materials which otherwise would be suitable for use as:

- a) Bedding Material unless other materials have been specified;
- b) Topsoil;
- c) Fertile soil; or
- d) Materials for re-use elsewhere on Site.

When otherwise suitable material from a trench is contaminated, the Contractor shall, to make up any shortfall, obtain (at his own expense if the contamination is due to his actions) suitable material from other excavations on the Site, or by opening up borrow pits, or by importing from commercial or other sources.

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Subject to the requirements of Clause 15.3.3, hard rock fragments and boulders from excavations that conform to the classification given in Clause 9.4 (inclusive) of Section 9 - Bulk Surface Excavations and Trenching shall be incorporated in the backfill. The Engineer may direct that such fragments and boulders be suitably mixed with other backfill material.

Stockpiled materials shall be arranged so as to not obstruct the Works, traffic or drainage. Surplus material not required for backfilling and re-instatement shall be removed to designated spoil dumps during the progress of the work.

15.3.9 Suitable Material Not Available

Where suitable material (Bedding Material, Main Backfill, Fill or Selected Fill, etc.) is not readily available from trench excavation or from other excavations for the Works within a free haul distance of 1.0 km, the Contractor shall, subject to the Engineer's approval, in each instance obtain suitable material from the following sources to replace the shortfall:

- a) From screened, washed or otherwise treated excavated material;
- b) From other excavations on the Site;
- c) By importing from borrow pits; or
- d) By importing from commercial or other sources.

15.3.10 Transport of Materials

Haul of material imported from non-designated Borrow pits or commercial sources will be regarded as free haul.

In the case of materials from excavations or from designated Borrow pits, the free haul distance within which the Contractor will be required to move material without separate compensation will be 1.0 km. Transportation of all such excavated material beyond 1.0 km will be regarded as overhaul.

15.4 CONTRACTOR'S EQUIPMENT

15.4.1 Control of Water

The Contractor shall use appropriate techniques or equipment such as pumps or well points for keeping the earthworks, excavations, embankments, terraces and trenches sufficiently free from water to enable him to construct the Works and to lay pipes true to line and level and to bed them soundly, all as specified in Section 8 – Dealing with Water.

15.4.2 Compaction Equipment

Equipment shall be suitable for the production of the end result required under the conditions applicable to the Site.

Compaction equipment used for applying the dynamic load, controlling the moisture content, and grading or mixing, shall be capable of achieving the compaction specified with the materials available for the construction of the Works.

For pipelines, ducts or cables, the Contractor may use mechanical compaction equipment but he shall select such equipment and operate it in such a manner that the pipeline, duct or cable is not unduly stressed, damaged or deformed. Heavy machine compaction shall not be used directly

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above the pipe until sufficient backfill has been placed to ensure that machine compaction loads transmitted to the top of the pipe are no greater than would be imposed by normal road traffic over a pipeline with cover of depth 800 mm.

15.5 CONSTRUCTION (PIPELINES)

15.5.1 Bedding and Backfilling for Pipelines

- a) The bottom of the trench shall be prepared as specified in Clause 9.5.9.
- b) The Contractor shall not place any bedding material on the excavated trench bottom, or continue to any new stage of backfilling until the prepared trench bottom or the surface of the underlying zone has been inspected and approved by the Engineer. The Contractor shall advise the Engineer whenever sections of trench have been excavated and trimmed, and when backfilling of a certain zone has been completed and is ready to receive the next layer.
- c) Trenches shall be backfilled as soon as possible after pipe laying to limit:
 - i) Thermal movements of the pipeline causing stress concentrations;
 - ii) Mechanical damage to coatings;
 - iii) Damage to the pipeline due to flotation should the trench fill with water; and
 - iv) Safety.

**TABLE 15/3
MAXIMUM LENGTH OF EXPOSED PIPE**

NUMBER OF PIPES LAID PER DAY (Note 1)	PRODUCTION RATE (Note 2)	MAXIMUM EXPOSED LENGTH
1-3	54 m – 57 m / working day	400 m
4	72 m – 76 m / working day	550 m
5	90 m – 95 m / working day	700 m

Notes:

1. Pipe lengths vary between 18 m and 19 m
2. Average rate of progress of the train of all sequential pipe construction processes

- d) In dealing with water as required in terms of Section 8 – Dealing with Water, the Contractor shall, subject only to such particular items as are scheduled for designated hazards, properly and adequately protect the Works from flooding and damage by storm water, flow from springs and seepage. The Contractor shall take every precaution to prevent water from any source entering the excavations and shall keep the pipe trench free from water while carrying out excavation, preparation of the trench bottom, placing the pipe bed and until the trench is backfilled to the level below the top soil.
- e) No timber or other organic materials shall be left in the excavation during backfilling without the written agreement of the Engineer.
- f) In built-up areas, barricades shall be clearly visible at night time and equipped with red warning lights.

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15.5.2 Pipe Bed and Bedding Cradle**15.5.2.1 Pipe Bed**

- a) As soon as the trench bottom has been passed by the Engineer, the bedding material for the pipe Bed shall be placed and compacted to the level and grade as specified over the full width of the trench. The thickness of the layer shall be minimum 200 mm unless otherwise specified by the Engineer. Where the cradle consists of soilcrete and the pipe is supported on sandbags (refer Clause 15.5.2.2), the thickness of the bed shall be reduced to 80 mm to compensate for the difference in procedure.
- b) The pipe shall be uniformly supported along its length at the required level and grade without interfering with the placement and compaction of the balance of the bedding material.
- c) The Contractor shall excavate holes for joints, stiffeners and pipe lifting bands and the trench shall not be considered ready for pipe laying until the pipe Bed and Joint Holes have been constructed by the Contractor and accepted by the Engineer.
- d) Where the trench bottom is too soft and waterlogged to permit placement and compaction of bedding material in the normal manner, the trench bottom shall be further excavated and a layer of crushed stone placed (see Clause 9.5.9 c)).The pipe Bed material shall then be placed as described.

15.5.2.2 Bedding Cradle

- a) After a pipe section has been placed in position and the joint completed, placing of the Bedding Cradle shall commence.
- b) During the placing of the Bedding Cradle, bedding material shall be placed and compacted in layers evenly on both sides of the pipe. During compaction the material shall be watered to optimum moisture content and compacted in layers not exceeding 150 mm in depth, to densities specified in Clause 15.7.
- c) The material in the 'wedges' formed by the curvature of pipe bottoms shall be compacted by hand punning horizontally and obliquely, and the layers by pneumatic rammers or vibratory rollers. The method shall be subject to the Engineer's approval. Whatever method is adopted, great care shall be exercised at all times to prevent damage to pipe coatings or disturbance of the pipe level and grade by upward forces, flotation or otherwise.
- d) If soilcrete is specified for the Bedding Cradle, the pipe shall be supported on sandbags placed on the prepared Bed underneath each pipe to elevate the pipe bottom about 120 mm above the Bed. The Contractor shall ensure that the pipe is properly supported on the sandbags. A minimum of 4 support positions per pipe shall be provided, evenly spaced along the pipe and on both sides of the pipe, and to the dimensions specified by the coating supplier.
- e) The soilcrete shall be placed in at least two consecutive lifts to prevent pipe flotation. It shall flow through the cavity underneath the pipe providing continuous support to the pipe. The Contractor shall allow the soilcrete to set sufficiently to gain enough strength (not less than 2 days after placing) to allow placing of the Selected Fill Blanket to commence.

15.5.3 Selected Fill Blanket

- a) Placing of the Selected Fill Blanket shall only proceed after acceptance of the Bedding Cradle by the Engineer.
- b) The Selected Fill Blanket shall be placed in layers not exceeding 150 mm depth in the loose, watered to optimum moisture content and compacted evenly in layers on both sides of the pipe to densities as specified. Compaction may be undertaken by pneumatic rammers or

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vibratory rollers. The method shall be subject to the Engineer's approval. Whatever method is adopted, great care shall be exercised at all times to prevent damage to pipe coatings or disturbance of the pipe level and grade by flotation or otherwise.

- c) The top of the completed Selected Fill Blanket shall be formed to an even surface prior to commencement of the Main Backfill.

15.5.4 Main Backfill

- a) Any deficiency of backfill material from excavations and trench excavations because of the removal of excessive quantities of organic material or clay, unsuitable parts of the trench bottom, or excessive quantities of hard rock material shall be made up from suitable surplus material from other excavations on the Site within the free haul distance. If, in the opinion of the Engineer, insufficient or no suitable material is available for this purpose from such excavations, and the shortage of such material has not been caused by the methods used by the Contractor, the Engineer shall authorise the Contractor, in writing, to import sufficient suitable material. The Contractor shall so arrange his work that the importation of backfill material is kept to a minimum in respect of both quantity and overhaul.
- b) After completion of the Selected Fill Blanket, the remaining trench depth shall be filled with excavated material or imported material both complying with Clause 15.3.3. The Main Backfill in the trench shall be placed in layers not exceeding 200 mm loose in depth and compacted in accordance with Clause 15.7 up to the underside of the fertile soil. The remainder of the trench shall be completely filled with fertile soil and topsoil, the volumes and thicknesses being similar to what were originally removed. It shall be loosely compacted as specified in Clause 15.7. The top of the topsoil may be mounded to 150 mm above surroundings ground level to provide for settlement, care being taken to reinstate the drainage measures as described below.
- c) Where backfilling is carried out by mechanical equipment, the method of working shall be subject to the Engineer's approval. Heavy equipment exceeding the allowable design traffic load on the pipe shall not be allowed to travel along or across the trench.
- d) Suitable material for Main Backfill shall be obtained from the stockpile along the trench side or from any part of the Works where there is a surplus, or shall be imported from borrow areas.
- e) As soon as trench backfilling has been completed over any portion of the pipeline all surplus material and debris shall be removed from the servitude area to a dumping site approved by the Engineer. Where the dumping site is outside the free-haul distance, the Engineers' authority in writing must be obtained for the operation.
- f) Precautions shall be taken to ensure that the natural drainage of the ground is not interfered with, especially where topsoil or final backfill is left mounded. All necessary cross drains shall be constructed and agricultural drainage berms and contours reinstated as backfilling progresses. Care shall be taken to prevent erosion of backfill by construction of the necessary cross drains and drainage berms.
- g) The Contractor shall be responsible for repairing any settlement of backfill and erosion of the servitude up to the end of the Defects Notification Period. He shall fill and level any settlement and/or erosion from time to time, as required by the Engineer and at the Contractor's expense.

15.5.5 Cleaning of Pipeline Servitudes

As soon as possible after the Main Backfill has been completed, the Contractor shall clean the pipeline servitude of all surplus materials and debris. The cleaning of the servitude shall not lag behind the pipe laying operation by more than 500 m. Should this happen the Engineer reserves the right to stop the pipe laying operation.

15.5.6 Gravel Road Crossings

Details of roads to be crossed are provided on the drawings.

In areas subject to road traffic loads and in such other areas as instructed by the Engineer, trenches shall be backfilled in layers of thickness (after compaction) not exceeding 150 mm and the Main Backfill shall be compacted to 93% of modified AASHTO maximum density in the case of cohesive soil or 98% in the case of non-cohesive soil.

Immediately after completion of the Main Backfill to the top of the road subgrade level of a trench that crosses or runs along a gravel road, the Contractor shall reinstate the road surface by filling the remainder of the trench with a well-graded and well-compacted approved hard-wearing gravel surface of thickness at least 150 mm and of quality equal to that of the existing road surface.

The gravel layer may be finished with a slight camber in order to allow for initial settlement but, particularly where the new gravel surface is transverse to the flow of traffic, shall not be left so far proud of the adjacent road surface as to cause excessive jolting of any vehicle proceeding at normal speed.

15.5.7 Wet/unstable Trench Bottoms

Refer to Clause 15.5.2.1 d) and Clause 9.5.9 c) of Section 9 – Bulk Surface Excavations and Trenching.

15.5.8 Concrete Encased Sections

Where shown on the Drawings and at additional areas as instructed by the Engineer, pipe sections crossing underneath streams and roads (excluding pipe jacking sections) shall be fully encased in Classes 15/19 or 30/19 concrete to the dimensions as shown on the Drawings over lengths as shown on the drawings or as instructed by the Engineer. The pipe trench for a concrete encased pipeline shall be excavated to the depth below the bottom surface of the pipe, as shown on the Drawings or as instructed by the Engineer, and to sufficient width to allow for the concrete to be placed to the full specified width. The bottom of the trench shall be trimmed to line and grade. The pipe laying procedure to be followed shall be as described below:

- a) In the event of wet trench conditions, a drainage system as described in Clause 9.5.9, or as instructed by the Engineer, shall be provided.
- b) An in-situ concrete screed of approximately 35 mm shall be placed on the trimmed bottom of the trench. This shall be followed by a 450 mm deep concrete bed, or as shown on the Drawings or as instructed by the Engineer, following placing of reinforcing, to the full width of the trench and to final design levels and grade.
- c) The pipe section shall not be placed within 24 hours of casting of the concrete bed. Sufficient space within the concrete bed shall be allowed for welding and application of the outer coating of the pipe joints. These spacers shall be filled with concrete after completion, testing and acceptance of the welds.
- d) Care shall be taken to ensure that the pipes do not move during welding.
- e) Suitable formwork and the necessary precautions to prevent flotation during concreting operations shall be provided. Methods adopted to prevent flotation shall not damage coatings or linings and shall be subject to approval by the Engineer. Notwithstanding this approval the Contractor shall at his own expense repair all damage to pipework caused by the methods adopted to prevent flotation.

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- f) Prior to the placing of concrete, the Engineer shall inspect and sign off on a hold point to ensure that no reinforcement is in contact with the pipeline and that any damage to the pipeline coating has been repaired.
- g) The concrete for the encasing shall be placed in such a way that all spaces under and around the pipe are completely filled. The concrete cover over the crown of the pipe shall be a minimum of 300 mm or as shown on the Drawings or instructed by the Engineer. Concrete casing shall be cast in one continuous operation until completed. No part of the concrete casing shall be closer than the maximum of 150 mm or one coupling width to any flexible joint in the pipeline.
- h) No backfill (refer Clause 15.5.4) over the concrete shall commence until at least 7 days after the concrete has been placed or until the concrete has attained a strength of at least 10 MPa.
- i) Hydrostatic testing of these pipe sections shall be undertaken after concrete encasement and will form part of the main pipe testing activities.

15.6 CONSTRUCTION (GENERAL EARTHWORKS, EMBANKMENTS, TERRACING AND STRUCTURE BACKFILL)

15.6.1 Placing and Spreading of Fill Material

Upon completion of the foundation treatment, materials required for the Fill layer concerned shall be deposited in place and prior to compaction shall be evenly spread over the whole of the designated area. The material shall be placed in such quantity that the thickness of any one layer, when measured after compaction, shall comply with the requirements specified or as established by trials conducted by the Contractor as agreed with the Engineer. Any new layer of less than 75 mm in compacted thickness shall be bonded to the previous layer by scarifying the previous layer to a depth of not less than 25 mm or to such greater depth so that the total compacted thickness of the new layer plus the scarified portion of the previous layer will not be less than 100 mm.

15.6.2 Construction of Fill near Structures

Where it is necessary to place Fill around structures forming part of the Permanent Works, it shall be placed and compacted evenly on all sides to minimize unbalanced loads on such structures. Such Fill shall not contain boulders or any other hard material which, in the opinion of the Engineer, may result in damage to the structure or incomplete compaction of the Fill.

Backfilling against water retaining structures will only be permitted after completion of testing for water tightness of the structure to the satisfaction of the Engineer.

At all Fills adjoining unfinished structures, such as retaining walls and large culverts, where the construction of the Fill or backfilling behind the structure cannot be undertaken simultaneously, the Fill shall be constructed in such a manner that the longitudinal slope of the surface of the Fill at any stage forms a continuous plane sloping towards the structure with a gradient not exceeding 10%. When the structure is completed, the remaining portion of the Fill shall be completed in a similar manner except that no heavy compaction equipment shall be used within 3.0 m of the structure. Backfilling of the structure shall be undertaken at the same time maintaining the backfill behind the structure at the same elevation as the adjoining Fill. No additional payment shall be made for constructing Fill in this manner.

15.6.3 Construction of Structure Backfill

Backfill within 1 000 mm of structures shall be considered as Structure Backfill. Structure Backfill shall be placed in loose layers not exceeding 300 mm and compacted evenly on all sides of the structure to minimize unequal loading on the structure. Such Structure Fill shall not contain boulders or any other hard material which, in the opinion of the Engineer, may result in damage to the structure or incomplete compaction of the Structure Backfill.

Where the use of conventional compaction equipment close to a structure is not possible, the material to be compacted shall be placed in loose layers of thickness not exceeding 200 mm and compacted by means of mechanical tampers to at least the density specified for the particular Structure Backfill.

15.6.4 Preparation of Material

15.6.4.1 General

All material used in the construction of any earthworks layer shall be reduced to the specified maximum permissible sizes during excavation by cross ripping, secondary blasting or other suitable means if necessary, before any breaking down as described below is attempted.

In order that earthworks layer thicknesses are not dictated by the presence of isolated larger rocks, the Engineer may order that material which cannot be broken down to the size generally obtainable for the rest of the material in the layer, be removed and disposed of as directed by the Engineer.

The material placed shall be thoroughly broken down throughout the layer by means of equipment suited to this purpose. The Contractor shall be at liberty to use what he considers to be the most suitable equipment, but in the event of disagreement between the Engineer and the Contractor as to the adequacy of the equipment used or the process employed, the material shall be given grid rolling as described in Clause 15.6.4.2. The Engineer may at any time require that all material be given normal grid rolling or any equal alternative treatment approved by him. During such processing the layer shall be frequently bladed to bring oversize material to the surface to facilitate breaking down.

When grid rolling cannot effectively break down the material to the required size, the Engineer may instruct the use of specialised equipment, such as heavy vibrating grid rollers and self-propelled tamping rollers, in order to break down the material.

The material shall be broken down to a size not exceeding two thirds of the layer thickness in the case of Fill and Selected Fill layers.

Where the coarse and fine fractions of the material are not uniformly distributed or have been allowed to become segregated, the material shall be thoroughly mixed on the surface by blading in successive cuts over the full depth of the layer with a motor grader, after the required amount of water has been added (see Clause 15.6.6). Such mixing shall continue until a uniform mixture of the various size fractions of the material has been obtained.

15.6.4.2 Grid Rolling

A cycle of grid rolling shall be taken to mean the following:

- a) The material shall be spread on a hard formation surface from the material heaps or windrow into a thin layer (maximum thickness of 50 mm);

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- b) Rolling shall be carried out with a grid roller of mass at least 13t, the knuckles in a good condition and travelling at a speed of at least 12 km/h, so that every portion of the layer is covered by four passes of the roller;
- c) The material shall be windrowed to the opposite side of the road or to the next blade width on terraces; and
- d) The process shall be repeated until all the material has been windrowed to the opposite side of the road or next blade width to the edge of the terrace. The material shall be checked for oversize and the oversize material removed or broken down by hand.

If the quantity of oversize material after a cycle of grid rolling is more than 5% by volume of the material in the layer, the Engineer may instruct that the above be repeated or the oversize material be spoiled.

15.6.5 Oversize Material

The Contractor shall exercise all reasonable care not to bring onto the Fill, material which cannot be broken down to the required size by processing on the Fill. This shall be avoided by proper selection in excavation or in borrow. Where such material is brought onto the Fill the Contractor shall, at his own cost, remove such material and dispose of it as instructed by the Engineer.

15.6.6 Watering and Mixing

Any water required before the material is compacted shall be added to the material in successive applications by means of water tankers fitted with sprinkler bars or by means of pressure distributors all capable of applying the water evenly and uniformly over the area concerned.

The water shall be thoroughly mixed with the material to be compacted by means of motor graders or other suitable equipment. Mixing shall continue until the required amount of water has been added and until a uniform mixture is obtained. Thereafter compaction may proceed.

The amount of water to be added shall be sufficient to bring the material to the optimum moisture content for the compaction equipment used and the density required, provided always that compaction shall not be attempted and will not be approved with materials not having "compaction moisture content" as defined in Clause 15.2.1. Should the material be too wet, due to rain or any other cause, it shall be harrowed or ripped and allowed to dry out to a moisture content conforming to the above requirements before compaction proceeds.

15.6.7 Compaction

15.6.7.1 Layer Compaction

Compaction shall be carried out in a series of continuous operations covering the full width of the layer concerned and the length of any section of a layer being compacted shall, wherever possible, be not less than 150 m nor more than can be properly compacted with the available equipment.

The Engineer reserves the right to instruct the Contractor to reduce the depth of any layer compacted in any single operation if the proper compaction of such a layer is not being achieved. The types of compaction equipment to be used and the amount of rolling to be undertaken shall be subject to the approval of the Engineer and shall be such as to ensure that specified densities are obtained without damaging lower layers or structures. During compaction the layer shall be maintained to the required shape and cross-section, and all holes, ruts and laminations shall be removed.

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The compacted layers shall be adequately drained and shaped to prevent water from standing on or scouring the finished work. Windrows shall be removed to facilitate drainage of water from the surface.

No material for a succeeding layer shall be placed if the underlying layer is softened by excessive moisture or prior to the Contractor seeking and obtaining the Engineer's approval for the underlying layer.

15.6.7.2 Classification of Compaction

For the purposes of measurement and payment the method of processing and the compaction of fill material shall be classified as described below. The Engineer shall decide beforehand on the classification of compaction to be employed, and the classification of material for purposes of excavation shall have no bearing on the classification of the compaction of material.

- a) Compaction to a minimum percentage of Mod AASHTO density:

Wherever a density requirement of a soil or gravel layer is specified in terms of a percentage of Mod AASHTO maximum dry density in this Specification or on the Drawings or when directed by the Engineer, the Contractor shall be at liberty to employ any type of compaction equipment he may choose in order to achieve such density over the full specified depth of the layer, provided always that he complies in all respects with the general requirements of this Specification and that the equipment employed is adequate and suitable for the purpose and is in no way detrimental to any part of the Works.

- b) Rockfill processing and compaction:

During the spreading and compaction process the material shall be compacted and broken down by means of grid or other suitable rollers and shall finally be compacted by means of vibratory rollers in accordance with the formula given below, in order to achieve a good mechanical interlock of the rock and a maximum compaction of the finer material in the interstices between the rock. The type of vibratory roller used, the operating speed, number of passes and the layer thickness shall be governed by the following formula:

$$\frac{Pe \cdot n}{h \cdot V} = 1\,500 \text{ (minimum)}$$

Where: Pe = total static and dynamic force per metre width, exerted by the vibratory roller at operating frequency and amplitude as given by the manufacturer (kN/m)

n = number of passes required

h = compacted layer thickness in metres

V = roller speed in metres per second

Operating frequencies shall be limited to between 20 and 30 Hz, the minimum operating amplitude shall be 1.6 mm, the maximum speed shall be 4 km/h and Pe shall not be less than 120 kN/m.

15.6.8 Finishing of Slopes and Surfaces

15.6.8.1 Slopes

Fill slopes shall be finished to neat lines with all loose rocks and un-compacted material removed. The degree of finish as required by the Engineer shall depend on the nature of the material used

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for the Fill slopes but it shall be as smooth as is consistent with the material involved and good workmanship. Boulders shall not be allowed to project out of the Fill or slope surface.

15.6.8.2 Surfaces

The final layer of the Fill shall be uniform and smooth and shall present a hard compact appearance free from elevations and depressions. Where the top surface of a Fill is to remain permanently uncovered it shall, if so instructed by the Engineer, be graded to a cross fall of 2% to prevent the formation of pools of standing water.

15.6.9 Protection of Fills

During construction, the Fill shall be kept well drained and protected at all times. All windrows shall be cut away after construction in order to prevent concentrated water flow on completed Fill layers, but where necessary flat berms shall be constructed to prevent undue erosion of Fill slopes. All permanent drains shall be constructed as soon as possible, plus sufficient additional temporary drains as may be necessary to protect the Fill, and they shall be maintained in good working order. Ruts and potholes developing in the Fill after completion shall be repaired, and damaged sections of the Fill shall be reshaped and re-compacted without additional payment.

All Fill slopes shall be maintained by the Contractor until final acceptance of the Fill. All erosion and flood damage to slopes shall be promptly repaired. Side drains discharging from cuts and all other drains shall be constructed in such a way that damage to Fill by erosion is avoided.

Proper precautions and temporary measures shall be taken in all cases in order to ensure that the method or procedure by which the Fill is constructed will not impose loads on structures, especially on unfinished structures, which may damage or overstress such structures.

Where the top surface of a Fill is to remain permanently uncovered it shall, if so instructed by the Engineer, be graded to a cross fall of 2% to prevent the formation of pools of standing water.

15.7 COMPACTION

Compaction of all material shall be done at "compaction moisture content" as defined in Clause 15.2.1.

The compaction of the Bedding Material shall be at least 90% of Mod AASHTO (T-180) maximum dry density.

The compaction for the Main Backfill, fertile soil and topsoil shall be to a density of at least 90% Mod AASHTO (T-180) maximum dry density. Compaction of the main backfill in road reserves shall be 90% Mod AASHTO (T-180) maximum dry density.

Fill for general earthworks, embankments and terracing material shall be compacted to at least 90% Mod AASHTO (T-180) maximum dry density. Sands, being for the purpose of this requirement specified as non-plastic sand with not less than 95% passing the 4.75 mm sieve, shall be compacted to a minimum in-situ dry density of 100% Mod AASHTO (T-180).

Selected Fill for general earthworks, embankments and terracing shall be compacted to at least 93% Mod AASHTO (T-180) maximum dry density. Non-plastic sand shall be compacted to a minimum in-situ dry density of 100% Mod AASHTO (T-180).

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Structure Backfill shall be compacted to at least 90% Mod AASHTO (T-180) maximum dry density. Non-plastic sand with not less than 95% passing the 4.75 mm sieve, shall be compacted to a minimum in-situ dry density of 100% Mod AASHTO (T-180).

The Contractor shall control the field compaction densities by means of the sand displacement method or any other method (e.g. nuclear density testing) as agreed with and approved by the Engineer. Frequencies of tests to be as specified.

15.8 TOLERANCES

15.8.1 Pipelines

15.8.1.1 Alignment and Grade

The deviation from the specified level of the invert and the specified dimensions of a trench and (for a height equal to at least the diameter of the pipe, culvert or duct, as applicable) of the lower part of the sides of the trench shall be such that the pipe may be laid and bedded in the trench within the tolerances specified for the pipeline.

15.8.1.2 Compaction Densities

At least 4 relative density determinations per density test shall be taken in the case of pipe Bed, Bedding Cradle, Selected Fill Blanket and Main Backfill. After outliers have been examined and replaced, density test results shall conform to the minimum values given in Table 15/4.

**TABLE 15/4
DENSITIES AND SAMPLE SIZES**

PRESCRIBED COMPACTION	UNIT OF MEASUREMENT	MINIMUM AVERAGE RELATIVE COMPACTION DENSITY PER TEST (4 DENSITY DETERMINATIONS AT LEAST)	MINIMUM VALUE FOR ANY SINGLE DENSITY DETERMINATION FOR THE FOLLOWING NUMBER OF DENSITY DETERMINATIONS					
			4	5	6	7	8	9
85%	Mod. AASHTO density	85.1	81.4	81.2	81.0	80.9	80.8	80.7
90%	Mod. AASHTO density	90.1	86.4	86.2	86.0	85.9	85.8	85.7
93%	Mod. AASHTO density	93.1	89.4	89.2	89.0	88.9	88.8	88.7
95%	Mod. AASHTO density	95.1	91.4	91.2	91.0	90.9	90.8	90.7
98%	Mod. AASHTO density	98.1	94.4	94.2	94.0	93.9	93.8	93.7

15.8.2 General Earthworks, Embankments and Terracing

15.8.2.1 Elevation

At least 50 elevation measurements shall be taken according to a stratified random pattern of each section of the completed Fill, and the specified levels shall then be determined. Outliers shall be identified and examined.

The lot/batch will be considered to comply with the requirements in respect of surface levels if, before any repair work is undertaken, at least 90% of the level measurements show a deviation from the specified elevations which is smaller than 25 mm. Isolated spots, where the surface elevations deviate by more than 30 mm from the specified elevations, shall be repaired to bring the deviation to within 25 mm.

15.8.2.2 Width

- a) Fill and Selected Fill: The horizontal measurement taken from the centre line of the Embankment or Terrace to the side of the Embankment or Terrace, shall deviate nowhere by more than 125 mm from the specified dimension when measured at any level.
- b) Cut slopes: The cut slopes shall be finished to a standard generally attainable with proper care and workmanship, where the nature of the excavated material is borne in mind. Care shall also be taken not to undercut any slopes which would cause sections to have a steeper slope than specified. All loose material shall be removed.
- c) Cut and Fill slopes requiring lining: The deviation of the final slope profile from a line joining any two points on the slope, 30 m apart, shall not exceed 150 mm.

15.8.2.3 Layer Thickness

At least 30, but preferable more, layer thicknesses shall be determined in accordance with a stratified random pattern for each lot/batch of completed layer work. Layer thicknesses may be determined by means of level measurements taken before and after construction of the layer in exactly the same position, but may be augmented by thickness measurements taken by means of holes made in the layer. Outliers shall be identified, disregarded, and if possible, replaced.

The lot/batch will be considered to comply with the requirements for layer thicknesses if:

- At least 90% of all the thickness measurements taken before any thickness repairs are made is equal to or greater than the specified thickness, minus 30 mm; and
- The mean layer thickness of the lot is not less than the specified thickness minus 10 mm. Isolated spots where the actual thickness is less than the specified thickness minus 40 mm shall be repaired so as to fall within the 30 mm tolerance.

15.8.2.4 Compaction Density

At least 4 relative density determinations per density test shall be taken for Fill and Selected Fill layers. After outliers have been examined and replaced, density test results shall conform to the minimum values given in Table 15/4.

15.9 TESTING**15.9.1 Testing by the Contractor****15.9.1.1 Testing for Pipelines****(a) Testing**

The Contractor shall carry out sufficient tests to satisfy himself as to the consistency of materials placed in the trench. The testing for consistency of soil materials shall at least include grading analysis and Atterberg Limits from routine sampling daily at each compaction production front for bedding, bedding cradle and selected fill. Any observed change in material colour or particle size shall trigger consistency testing.

In addition the Contractor shall carry out routine density control tests to ensure that the specified densities are being attained and shall make out-of-roundness measurements of all pipes laid prior to backfilling and on completion of backfilling. Records of the test results and measurements and the working sheets used shall be kept in a systematic manner and shall be submitted to the Engineer within 24 hours of being completed or available.

All Site testing carried out by the Contractor shall be performed in an approved suitably equipped and staffed laboratory by competent and sufficiently experienced laboratory staff. Off-site testing shall be carried out by a recognized testing institution, an approved laboratory or a firm approved by the Engineer.

(b) Density Testing

The Contractor shall carry out sufficient density tests (each comprising at least 4 density determinations) as approved by the Engineer to ensure that the specified densities are being attained for each component of the trench backfill. The minimum testing frequency and requirements are given below:

Main Backfill:	Frequency	- 4 density tests per 200 m ³ - At least 3 tests per layer
	Minimum density	- See Clause 15.7
Bedding Material:	Frequency	- 4 density tests per 100 m ³ - At least 3 tests per layer
	Minimum density	- See Clause 15.7

(c) Out-of-Roundness

When the pipe is laid in position in the trench and prior to the commencement of any backfilling layer (Bedding Cradle, Selected Fill Blanket and Main Backfill), the Contractor shall measure with an approved measuring device and record the horizontal and vertical internal pipe dimension at six equally spaced intervals along each pipe length recording the number of the pipe and the chainage at which it was installed. When the Main Backfill has been completed to ground level, the Contractor shall re-measure the horizontal and vertical internal pipe dimension following the same procedure. Any out-of-roundness over and above the maximum allowable shall be corrected.

Measurements shall be taken to an accuracy of 1.0 mm and the Contractor shall provide approved equipment and adequately trained labour to carry out the measurements. The recorded information and measurements shall be submitted to the Engineer within 24 hours of the time that any measurement was taken.

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The out-of-roundness shall be defined as the difference between the vertical internal pipe dimension and the internal diameter of the pipe with zero out of roundness (ID), divided by the ID times 100 to obtain a %. The “maximum allowable out-of-roundness” shall be plus or minus 2% for pipes with cement mortar lining and plus or minus 3% for pipes with any other type of lining and coating.

If the out-of-roundness after the placing of the Main Backfill exceeds the “maximum allowable out-of-roundness”, the Contractor shall remove the full depth of the Main Backfill, the Selected Fill Blanket and the Bedding Cradle over the length of pipe that shows excessive out of roundness. After the removal of each of the three layers, the Contractor shall measure the horizontal and vertical internal pipe dimension as specified above. The Contractor shall then test the Bedding for material quality (soil type) and compaction.

The Contractor shall prepare the following Method Statements prior to commencing with the relevant work:

- Removal of the backfilling layers without damaging the pipe and pipe coating; and
- After testing the Bedding, proposed methods to rectify the out-of-roundness based on the measurements and tests.

The Method Statements shall be subject to the Engineer’s approval before commencing of the works.

15.9.1.2 Testing for General Earthworks, Embankments and Terracing

(a) Testing

The Contractor shall carry out sufficient tests to satisfy himself as to the consistency of materials. The Contractor shall carry out routine density control tests to ensure that the specified densities are attained. Tests for the maximum dry density and optimum moisture content, Atterberg Limits, CBR and CBR swell and particle size analysis shall also be carried out. Records of the test results and measurements and the working sheets used shall be kept in a systematic manner and shall be submitted to the Engineer within 24 hours of being completed or available.

All Site testing carried out by the Contractor shall be performed in an approved suitably equipped and staffed laboratory by competent and sufficiently experienced laboratory staff. Off-site testing shall be carried out by a recognized testing institution, an approved laboratory or a firm approved by the Engineer.

(b) Density Testing

The Contractor shall carry out sufficient density tests (each comprising at least 4 density determinations) as approved by the Engineer to ensure that the specified densities are being attained.

The minimum testing frequency and requirements are given below:

Fill:	Frequency	- 4 density tests per 100 m ³ - At least 3 tests per layer
	Minimum density	- See Clause 15.7
Selected Fill:	Frequency	- 4 density tests per 100 m ³ - At least 3 tests per layer
	Minimum density	- See Clause 15.7

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Structure Backfill:	Frequency	- 4 density tests per 100 m ³ - At least 3 tests per layer
	Minimum density	- See Clause 15.7

15.9.2 Testing by the Engineer

In addition to the control testing carried out by the Contractor, the Engineer may order additional density tests to be carried out to monitor and accept the compaction of any part of the trench backfill. If the results of such density tests (which shall not be taken on the bedding material directly above the pipe) show that the material has been compacted to a density equal to or in excess of the applicable specified value (see Clause 15.7), the compaction will be accepted. If the density is found to be below the specified value, the Engineer may order the re-compaction of the backfill at the Contractor's expense. The Contractor shall bear the cost of all monitoring and acceptance of density tests.

15.10 MEASUREMENT AND PAYMENT**15.10.1 General**

The rates tendered under this Section shall not include for the general obligations, Contractor's Equipment and work deemed to be covered by the items provided in Section 1 – General.

15.10.2 Volume of Bedding Materials

The volume of bedding material to be measured for payment purposes will be computed from:

- The external dimensions of the pipe and the trench width as specified in Table 9/2 of Section 9 - Bulk Surface Excavations and Trenching; and
- The depth of each bedding layer as shown on the Drawings.

No allowance will be made for material bulking. The volume of the pipe will be excluded from the volume calculation. The solid volume calculation shall be based on the excavation payment line as defined on the Drawings. However the Contractor shall make allowance in his rates for some overbreak and battered trench sides that is expected to occur during excavation and trench blasting.

15.10.3 Volume of Fill Materials

Measurement of the different categories Fill will be the net volume of compacted Fill, calculated from the dimensions, lines and levels of the Fill given on the Drawings and agreed ground level surveys. No Fill outside the specified dimensions, lines and level will be included in the measurements.

The payment line is a vertical payment line as indicated on the drawings. The Contractor to make allowance in his rates for any materials that is required over and above the vertical payment line.

15.10.4 Overhaul

Overhaul distances will be measured to the nearest 0.1 km from the end of the 1.0 km free haul, using the shortest practical route agreed with the Engineer from the point of loading to the point of dumping in one direction only as follows (Distance categories to follow the free haul):

- a) Between 1 km up to and including 3 km
- b) Between 3 km up to and including 5 km
- c) Between 5 km up to and including 7 km
- d) Between 7 km up to and including 9 km
- e) Between 9 km up to and including 11km
- f) Between 11 km up to and including 13 km
- g) Distances further than 13 km Unit: m³.km

The rate tendered shall include full compensation for all costs associated with loading, transporting and tipping of material the greater distance than the free haul, including equipment, materials, fuel and personnel.

No payment will be made against this item (overhaul) for reinstatement of the Contractor's working and accommodation areas (including the areas designated for the Engineer's use) and temporary roads. Compensation for such work shall be included in the relevant items in Section 1 – General.

15.10.5 Scheduled Items for Pipelines**15.001 Placing of bedding material, fertile soil and main backfill Unit: cubic metre (m³)**

Separate items will be measured for the placing of fertile soil and material for the Bed, Bedding Cradle, Selected Fill Blanket and Main Backfill. The rates shall cover the cost of handling, placing and compaction of the material along the length of the trench in accordance with the Specification and to suit the Contractor's methods of working.

15.002 a) Placing of soilcrete bed and bedding cradle Unit: cubic metre (m³)

The rate shall cover the cost of placing of sandbags as prescribed, the provision of formwork where required and handling, mixing and placing of the soilcrete along the length of the trench in accordance with the Specification and to suit the Contractor's methods of working.

15.002 b) Placing of cement stabilised soil bed and bedding cradle Unit: cubic metre (m³)

The rate shall cover the cost of handling, mixing and placing of the cement stabilized soil along the length of the trench in accordance with the Specification and to suit the Contractor's methods of working.

15.003 Provision of bed material**Unit: cubic metre (m³)**

a) Without screening from trench

The rate shall cover the cost of obtaining the Bed material within the free haul distance from trench excavation and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

b) With screening from trench

The rate shall cover the cost of obtaining the Bed material within the free haul distance from trench excavation, screening of the material and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

c) Without screening from borrow pits

The rate shall cover the cost of obtaining the Bed material from borrow pits and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

d) With screening from borrow pits

The rate shall cover the cost of obtaining the Bed material from borrow pits, screening of the material at the borrow pit site and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

e) Cement for stabilisation of soil

The rate shall cover the cost of obtaining the cement, delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

15.004 Provision of bedding cradle material**Unit: cubic metre (m³)**

a) Without screening from trench

The rate shall cover the cost of obtaining the Bedding Cradle material within the free haul distance from trench excavation and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

b) With screening from trench

The rate shall cover the cost of acquiring the required Bedding Cradle material within the free haul distance from trench excavation, screening of the material and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

c) Without screening from borrow pits

The rate shall cover the cost of obtaining the Bedding Cradle material from borrow pits and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

d) With screening from borrow pits

The rate shall cover the cost of acquiring the required Bedding Cradle material from borrow pits, screening of the material at the borrow pit site and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

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e) From commercial sources

The rate shall cover the cost of acquiring the Bedding Cradle material, delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working. No additional payment will be made for haulage of imported materials from commercial sources.

15.005 Provision of soilcrete**Unit: cubic metre (m³)**

a) Without screening from trench

The rate shall cover the cost of obtaining material for soilcrete within the free haul distance from trench excavation and delivering to and offloading at points alongside the trench to suit the Contractor's methods of working, and supplying cement and water and sandbags as prescribed.

b) With screening from trench

The rate shall cover the cost of obtaining material for soilcrete within the free haul distance from trench excavation and delivering to and offloading at points alongside the trench to suit the Contractor's methods of working, screening, and supplying cement and water and sandbags as prescribed.

c) Without screening from borrow pits

The rate shall cover the cost of obtaining material for soilcrete from borrow pits and delivering and offloading to points alongside the trench spaced to suit the Contractor's methods of working, and supplying cement and water and sandbags as prescribed.

d) With screening from borrow pits

The rate shall cover the cost of obtaining material for soilcrete from borrow pits, screening of the material at the borrow pit site and delivering and offloading to points alongside the trench spaced to suit the Contractor's methods of working, and supplying cement and water and sandbags as prescribed.

e) From commercial sources

The rate shall cover the cost of acquiring material for soilcrete and delivering and offloading to points alongside the trench spaced to suit the Contractor's methods of working, and supplying cement and water and sandbags as prescribed to suit the Contractor's methods of working. No additional payment will be made for haulage of imported materials from commercial sources.

15.006 Provision of selected fill blanket**Unit: cubic metre (m³)**

a) Without screening from trench

The rate shall cover the cost of obtaining the Selected Fill Blanket material within the free haul distance from trench excavation and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

b) With screening from trench

The rate shall cover the cost of obtaining the Selected Fill Blanket material within the free haul distance from trench excavation, screening of the material and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

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c) Without screening from borrow pits

The rate shall cover the cost of obtaining the Selected Fill Blanket material from borrow pits and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

d) With screening from borrow pits

The rate shall cover the cost of obtaining the Selected Fill Blanket material from borrow pits, screening of the material at the borrow pit site and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

e) From commercial sources

The rate shall cover the cost of acquiring the selected Fill Blanket material, delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working. No additional payment will be made for haulage of imported materials from commercial sources.

15.007 Provision of main backfill material**Unit: cubic metre (m³)**

a) From trench excavation

The rate shall cover the cost of obtaining the Main Backfill material within the free haul distance from trench excavation within the confines of the pipeline servitude and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

b) From borrow pits

The rate shall cover the cost of obtaining the Main Backfill material from borrow pits and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

15.008 Bedding foundation/subsoil drainage at wet/unstable trench bottom

a) Supply and place crushed stone for Layer no 1

Unit: cubic metre (m³)

b) Supply and place geotextile for Layer no 1

Unit: square metre (m²)

c) Supply and place well graded compacted dump rock for Layer no 2

Unit: cubic metre (m³)

d) Supply and place geotextile for Layer no 2

Unit: square metre (m²)

The rates for the (a) and (c) shall cover the cost of acquiring the crushed stone and dump rock from commercial or other sources and placing and compacting of the material within the geotextile. The rate for (b) and (d) shall cover full compensation for procuring, furnishing and laying the geotextile as specified including laps and wastage. Measurement will be the net area of geotextile fabric laid, excluding overlaps, and calculated from the dimensions as specified and/or given on the Drawings for the different types and locations.

15.009 Encasing of pipes in concrete**a) Concrete****Unit: cubic metre (m³)****b) Reinforcement****Unit: ton (t)**

For concrete, separate items will be scheduled for each grade of concrete specified. The volume will be computed from the dimensions of the concrete as indicated on the Drawings. The rate shall cover the cost of materials and work and encasing the pipe in concrete including the cost of formwork (if any), temporary supports, haulage and placement. No overhaul is applicable for this item.

For reinforcement, the steel will be measured net by mass of all bars. The mass will be computed from the nominal bar size and the nominal mass per unit length. The rate shall cover the cost of supply, cutting, bending, placing in position and fixing of the reinforcement and supporting steel and the provision of all spacer devices and binding wire.

15.010 Overhaul**Unit: cubic metre (m³)**

Overhaul distances will be measured to the nearest 0.1 km from the end of the 1.0 km free haul, using the shortest practical route agreed with the Engineer from the point of loading to the point of dumping in one direction only as follows (Distance categories to follow the free haul):

- a) Between 1 km up to and including 3 km
- b) Between 3 km up to and including 5 km
- c) Between 5 km up to and including 7 km
- d) Between 7 km up to and including 9 km
- e) Between 9 km up to and including 11 km
- f) Between 11 km up to and including 13 km
- g) Distances further than 13 km Unit: m³.km

The rate tendered shall include full compensation for all costs associated with loading, transporting and tipping of material applicable to the greater distance in a distance category over and above the free haul distance, including equipment, materials, fuel and personnel.

15.011 Provision of material to replace unsuitable material from trench bottom or to provide supporting earthworks **Unit: cubic metre (m³)**

- a) From trench excavation

The rate shall cover the cost of obtaining the identified material within the free haul distance from trench excavation within the confines of the pipeline servitude and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

- b) From borrow pits

The rate shall cover the cost of obtaining the identified material from borrow pits and delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working. The first 1km is regarded as free haul.

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c) From commercial sources

The rate shall cover the cost of obtaining the identified material, delivering to and offloading at points alongside the trench spaced to suit the Contractor's methods of working.

No additional payment will be made for haulage of imported materials from commercial sources.

15.012 Placing of material to replace unsuitable material from trench bottom or to provide supporting earthworks **Unit: cubic metre (m³)**

Separate items will be measured for the placing and compaction of the material. The rates shall cover the cost of handling, placing and compaction to the specified density of the material along the length of the trench in accordance with the Specification and to suit the Contractor's methods of working.

15.013 Extra over 15.003(b), 15.003(d), 15.004(b), 15.004(d), 15.005(b), 15.005(d), 15.006(b) and 15.006(d) for crushing and screening of material **Unit: cubic metre (m³)**

The rate shall include full compensation for all additional work required to crush and screen material to ensure a maximum particle size of not exceeding 3 mm and including 3 mm. Refer to the requirements of the notes to Table 15/1 in this regard.

15.10.6 Scheduled Items for embankments, terraces and structure backfill

15.014 Construction of embankment and structure backfill

a) Compaction to specified density **Unit: cubic metre (m³)**

b) Rockfill processing and compaction **Unit: cubic metre (m³)**

Fill material shall be classified by the Engineer in terms of a) or b) above.

The rates shall include full compensation for all work required to construct the Fill or Structure Backfill including hauling material from excavations, borrow pits, road cuttings or temporary stockpiles where such stockpiles are provided by the Contractor, offloading, preparing, spreading, breaking down, compacting and testing of materials, removal to spoil of oversize material, shaping and protecting and maintaining the Embankment, Terrace or Structure Backfill.

Where the material is to be obtained from stockpiles, the rate shall also cover the cost of loading the material at the stockpile for transport to the place of re-use. The first 1 km is regarded as free haul.

For Embankments and Terraces, the rate shall also include for any additional difficulty in placing Fill within 3.0 m of a structure where the use of heavy vibration equipment is prohibited.

15.015 Finishing of slopes**Unit: square metre (m²)**

Measurement will be the area of slopes finished off as specified. The areas shall be measured from levelled cross-sections and shall be the area between the shoulder breakpoint and the toe of the cut or Embankment. The areas occupied by side drains or any other drains shall not be included.

The rates tendered shall include full compensation for all work required for finishing off the slopes as specified, including the loading, hauling and disposal to designated spoil areas of any material brought down during finishing operations.

15.016 Overhaul**Unit: cubic metre (m³)**

Overhaul distances will be measured to the nearest 0.1 km from the end of the 1.0 km free haul, using the shortest practical route agreed with the Engineer from the point of loading to the point of dumping in one direction only as follows (distance categories to follow the free haul):

- a) Between 1 km up to and including 3 km
- b) Between 3 km up to and including 5 km
- c) Between 5 km up to and including 7 km
- d) Between 7 km up to and including 9 km
- e) Between 9 km up to and including 11km
- f) Between 11 km up to and including 13 km
- g) Distances further than 13 km

Unit: m³.km

The rate tendered shall include full compensation for all costs associated with loading, transporting and tipping of material applicable to the greater distance in a distance category over and above the free haul distance, including equipment, materials, fuel and personnel.