

SECTION R5

Earthworks

R5 01 Scope

The work covered by this section of the Specification consists in furnishing all labor, equipment, supplies and materials, and performing all operations in connection with soil or salt layer stripping, excavation, construction of embankments, excavation and backfilling around structures, and all incidental grading, all operations of "Embankment in Place" and in strict accordance with this section of the Specification and the applicable drawings.

In the provisions which follow, the term "Earthworks" will be used as a general term to designate all classes of grading, leveling, ditching and earth moving, and all other excavating and embankment construction work.

R5 02 General notes, definition, classification

1. **Accuracy of Work:** All earthworks shall be performed accurately to the lines, grades and cross-sections as shown or indicated on the Drawings.

The cross-sections in embankments and cuttings showing the levels of the road formation shall be subject to such variation from the typical sections shown on the Drawings as may be necessary to provide satisfactory superelevation on curves and to take care of special conditions encountered at intersections and elsewhere.

2. **Formation Level:** Formation level on embankments and in cuttings shall be the surface level of the underside of the sub-base, or where no sub-base is specified, of the underside of the base. The levels and tolerance or irregularity of the surface shall be within the limits specified.

Any permitted deviation below the true levels shall be made up in sub-base or base material compacted as specified, which shall not be measured for payment.

3. **Classification:** Pay excavations, as hereinafter defined and limited, shall be of five kinds which shall be designated as follows:

- (1) Drainage excavations.
- (2) Structural excavations.
- (3) Special borrow excavations.
- (4) Embankment in place.
- (5) General excavations.

All excavations shall be on a two-classification basis, (a) solid rock and (b) common excavations as hereinafter defined.

4. Definitions:

(1) Definitions of earthworks material.

- (i) **Topsoil** is a soil which on visual examination can be seen to be broken down by agricultural cultivation and/or is seen to be capable of supporting growth. It shall include all old cut turf which is no longer suitable for turfing.
- (ii) **Suitable material** shall comprise all that which is acceptable in accordance with the Contract for use in the Works and which is capable of being compacted in the manner specified in this Specification to form a stable fill having side slopes as indicated on the Drawings.
- (iii) **Unsuitable material** shall mean other than suitable material and unless accepted by the Engineer's Representative shall include:
 - (a) Material from swamps, marshes or bogs and soils containing **more than 12% organic** matter when tested in accordance with Test 8 of BS 1377 (1975).
 - (b) Peat, logs, stumps and perishable material.
 - (c) Material susceptible to spontaneous combustion.
 - (d) **Salty or gypseous soil containing more than 10% of soluble salts when used in the top 30cm of the embankment and 20% in rest** or the embankment.

The test should be run according to the Earth Manual of U.S. Bureau of Reclamation Appendix E8 with maximum dilution of 1:50
 - (e) **Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45** unless otherwise instructed in the Drawings and/or otherwise permitted by the Engineer.
- (iv) **'Rock' Excavation:** 'Rock' shall include only hard material or rock found in ledges or masses in its original position which in the opinion of the Engineer's Representative is impossible to remove by heavy mechanical excavating plant or by heavy duty hydraulic ripper, or by approved pneumatic tools, and which would normally be removed by blasting with explosives, or by drilling and broaching with wedges and sledge hammers if removed by hand. Also individual boulders or detached pieces of rock exceeding one quarter cubic meter in size in trenches one meter in width or less and exceeding one half cubic meter in general excavations and in trenches over one meter width, necessitating blasting as above. Removal of rock will only be classified as Rock Excavation when it is not possible to rip and excavate by a bulldozer with 350 HP and one ripper tooth. All other excavation of rippable very weak rock and very hard soils will be classified as common excavation. Should any difference of opinion arise between the Contractor and the Engineer's Representative whether any hard material is 'Rock' or is qualified for classification as 'Rock' according to the means required for its removal, then the matter shall be referred to the Engineer before any material is disposed of or covered up and his decision shall be final.
- (v) **Common Excavation** shall include all material not classified as rock and boulders or detached rock in pieces measuring less than the respective sizes specified in the foregoing clause, not requiring the same means of removal as 'Rock'.

5. Storage and Handling of Explosives and Blasting

- (i) The Contractor shall at all times observe and comply with all State Laws, Regulations and Rules which in any manner pertain to the handling, transportation and storage of explosives and the safety of persons and property.
- (ii) The Contractor shall only store explosives in a licensed or approved store or magazine provided with a separate compartment for detonators. The Contractor shall provide proper buildings for the store or magazine in locations to be approved by the Engineer as suitable for the storage of explosives in manner and quantities to be approved: he shall also be responsible for the prevention of any unauthorized issue or improper use of any explosives brought on the Works.

Only responsible and experienced men shall be employed for handling explosives which shall be used in the quantities and manner recommended by the manufacturers and in conformity with the statutory regulations.

- (iii) When blasting is carried out, particularly in rock, the Contractor shall ensure, by adherence to proper safety distances and by the use of heavy blasting mats where directed by the Engineer, that no damage or injury is caused to persons, livestock or property on or off the Site. The shots shall be properly loaded and covered and only moderate charges shall be used unless authorized in writing by the Engineer's Representative. A register shall be kept by the Contractor of all explosives used so that a check can be made by the Engineer's Representative.
- (iv) Blasting shall be restricted to whatever hours the Engineer's Representative may prescribe. If in the opinion of the Engineer's Representative blasting would be dangerous to persons or adjacent structures or is being carried out in a reckless manner, he may prohibit it and order the rock to be excavated by other means. The use of powder or other explosives by the Contractor in large blasts as in seams, drifts shafts, pits or large holes is prohibited unless authorized in writing by the Engineer.

Where blasting is proposed. adjacent to a structure, either existing or under construction, special care shall be taken when blasting in wet ground and irrespective of the weight of explosive, the written permission of the Engineer's Representative shall be obtained for each location or series of locations. The Contractor shall carry out preliminary site trials, and satisfy the Engineer that safe values of vibration amplitude and particle velocity are obtained.

Unless otherwise agreed by the Engineer the amplitude shall not exceed 0.20mm and the particle velocity shall not exceed:

50mm/sec where blasting is confined to single events.

25mm/sec where blasting is continuous.

Vibrograph readings shall be recorded throughout the period of blastings for urban locations or in the vicinity of any buildings or structures, or as required by the Engineer.

- (v) The Contractor shall provide at the explosive store the necessary watchman day and night and shall make his own arrangement for safe transport of explosives.

R5 03 Pay excavation description

1. **General Excavation:** Pay excavation shall comprise all excavation made within the net lines of the excavation cross-sections and above the excavation finished grades (formation levels) established by the Engineer. The excavation shall be carried out so as to avoid any under cutting and consequent instability of the finished sideslope.

2. **Excavation for Sewers:** In connection with excavation for sewers, pay excavation shall be limited to the pay widths and depths set forth on the Drawings.

3. **Excavation for Culverts and Drains:** In connection with the excavation for pipe culverts, pipes, siphons, pipe drains and tile drains, pay excavation shall be limited to excavation of specified or required depth and to a width equal to the outside diameter or width of the pipe, tile or culvert. In all cases involving sewers, pipes and drains, where the Drawings and Specification for trench width in Sections R3, R3A and R4 or Special Conditions of Contract indicate specific widths of excavation, it shall be understood such define the widths of pay excavation, and overbreak will not be allowed.

4. **Excavation for Structures:** In connection with the box culverts, bridges, abutments, piers, retaining walls, headwalls, partition walls and like structures, pay excavation shall be limited to excavation within vertical planes parallel to and coincident with the net lines of the footings or bases of the structures.

5. **Work not being a part of finished work:** Removal of overburden from pits and quarries, excavation of rock, gravel and other material for use in surfacing or structures, excavation for haulage roads, excavation for detour roads and temporary roadways and other excavation (borrow excavation excepted) which is not directly a part of the finished work shall not be considered pay excavation unless otherwise specifically so provided in the Special Specification of Particular Application.

6. **Grading and Maintaining:** Excavation involved in grading and maintaining road beds, roadways, subgrades, bases and foundations and excavation involved in backfilling and other re-handling and re-shaping of materials previously excavated shall not be considered pay excavation unless otherwise specifically so provided in the Special Specification of Particular Application.

7. **Excavation outside the net line:** Excavation outside of the net lines or road bed excavation cross-sections specified by the Engineer will be considered pay excavation only when such excavation is overbreak from the sides of excavation, which overbreak in the opinion of the Engineer's Representative could not have been avoided or foreseen by an experienced Contractor and caused the Contractor material expense for its removal.

R5 04 Roadway area preparation

1. **Removal of Unsuitable Material:** In the event of unsuitable material as decided by the Engineer's Representative and defined in Clause R5 02-4 being found on the site of any embankment, cutting, bridge or drainage structure and borrow areas, the Contractor shall remove such material to the depth indicated on the Drawings or as directed by the Engineer's Representative in writing. No payment will be made for quantities of unsuitable material exceeding those stated in the Bill of Quantities unless the approval in writing of the Engineer's Representative is obtained prior to carrying out the work. Materials so removed shall be disposed of outside the Right of Way.

2. Diversions or Reshaping of Watercourses: Where directed by the Engineer's Representative streams or watercourses crossing or adjacent to the Works shall be diverted, enlarged or straightened.

Where in diversions or reshaping of streams or watercourses the original channels lie within the earthworks, such channels shall be cleaned of all vegetable growth and soft deposits and filled with approved material compacted in accordance with the Clause R5 11-4 hereof.

3. Intercepting Ditches to Protect Cuttings and Embankment: Open ditches to protect cuttings and embankments shall be constructed in accordance with the Drawings or as directed by the Engineer. Where possible intercepting ditches shall be constructed in advance of general earthworks in cuttings and embankments. Unless otherwise directed they shall be 30cm wide at the invert (bottom), of an average depth of 50cm and with the sides trimmed back to a slope of 1 $\frac{1}{2}$ to 1.

The inverts shall be accurately graded so as to carry off the water to the outlet determined upon. For ditches blasted out in rock the sides shall be roughly trimmed to leave firm slopes. The material excavated from ditches shall, if considered suitable by the Engineer's Representative, be deposited in the embankments or otherwise disposed of as directed.

4. Underdraining of Embankments: If ordered by the Engineer's Representative the foundation of embankments and the formation in cuttings shall be provided with under-drains or sub-drains. Trenches shall be excavated to the dimensions indicated, their inverts graded to outfall and lined with precast slabs, stone pitching or with compacted crushed stone where shown on the Drawings or directed by the Engineer's Representative, if necessary compacted by ramming.

Where springs or seepages are encountered, or at other land drain locations, approved clay tile pipes shall be laid open jointed in the trenches which shall then be carefully backfilled with granular filter material to form French drains as specified in Section R4.

R5 05 DRAINAGE EXCAVATION

1. Description: Drainage excavation shall comprise and include the furnishing of equipment and labor and performing all operations in connection with the pay excavation lying outside road formation excavation cross-section as follows:

- (i) the installation of pipe culverts, pipe siphons, pipe drains and sewers.
- (ii) the excavation lying below the established invert grade, flow line grade or floor for pipe culverts, pipe siphons, pipe drains, tile drains and sewers.
- (iii) the moving or salvaging of pipe culverts, pipe siphons, tile drains and sewers.
- (iv) the shaping of slopes and ditches to form inlet basins to culverts and in the construction of miscellaneous structures, where such shaping and construction is specifically called for on the Drawings.
- (v) the excavation required in construction of inlet ditches, outlet ditches, diversion ditches, drain ditches, canals, channel changes and other ditches (excepting cut ditches, borrow ditches and other ditches in road bed section) having a bottom width of 2m or less.

2. **Excavation for Pipelines:** The width of trenches for pipes and special requirements for excavation shall be as specified under 'Pipe Laying' in Sections R3, R3,~ and R4.

Should the Contractor desire to use mechanical appliances for excavating trenches or for laying pipes he shall submit his proposals for the Engineer's Representative's approval. which will not relieve the Contractor from responsibility for damages to pipes, mains, etc.

3. **Timbering:** The sides of pits, trenches and other excavations shall where required be adequately timbered and supported to the satisfaction of the Engineer's Representative and all such excavations shall be of sizes sufficient to enable the pipes and concrete to be laid accurately, and proper refilling and ramming to be carried out.

4. **Pumping:** Trenches and headings shall be kept free from water until, in the opinion of the Engineer's Representative, any concrete or other works therein are sufficiently set and the Contractor shall, at his own expense, construct any sumps of temporary drains that the Engineer's Representative may deem necessary. The Contractor shall make good at his own expense any damage caused by prolonged and excessive pumping and shall take all precautions necessary for the safety of adjoining structures and buildings by shoring or otherwise during the time the trenches are open.

5. **Backfilling:** All backfilling to pipe trenches shall be as specified in Sections R3, R3A and R4. Filling shall be placed equally on both sides of the pipe and stepped so as to avoid unequal pressures. Shoring and other supports shall be removed as the filling proceeds and no timber supporting members shall be covered with filling material.

R5 06 Structural excavation

1. **Description:** The work covered by this Section consists in furnishing all equipment, labor, material and in performing all operations in connection with the structural excavations. Structural excavation shall comprise and include all pay excavation lying outside the road bed excavation cross-section required in connection with the construction of bridges, box and arch culverts, abutments, piers, retaining walls and partition walls. The work shall be performed in strict accordance with this Section of the Specification and the applicable Drawings.

2. **Inspection:** The Contractor shall notify, the Engineer's Representative before starting any excavation. From time to time during the progress of excavation the Engineer's Representative will examine the character of material being taken out. He shall have authority to stop the excavation at any time to make bearing tests and the Contractor shall give any assistance which the Engineer's Representative may desire in making such tests for which there will not be an extra payment.

3. **Depth and Dimensions of Footings:** Pits and trenches for foundations of structures shall be excavated to the levels and dimensions shown on the Drawings or to such other dimensions as the Engineer's Representative may direct.

The Engineer may require the Contractor to excavate below the foundation levels shown on the Drawings or he may order him to stop when suitable foundation material is encountered.

4. **Bottom of the Excavation:** The bottom of all excavations shall be carefully graded and if required by the Engineer's Representative stepped or benched horizontally. All excavations shall be taken out as nearly as possible to the exact dimensions of the foundations to minimize backfilling. In excavations for foundations of structures a bottom layer of soil

shall be left in place temporarily and subsequently removed only when the concrete is about to be placed, in order that softening or deterioration of the surface of the excavations by exposure may be avoided so far as possible. The thickness of the layer will depend on the type of soil and will be determined by the Engineer's Representative. Any pockets of soft material or loose rock in the bottoms of pits and trenches shall be removed as directed and the cavities so formed filled with concrete Class E as specified in Clause B8 09. After the completion of placing of any blinding concrete required by the Contract, no trimming of the side faces shall be carried out for 24 hours. When any excavation has been taken out and trimmed to the levels and dimensions shown on the Drawings or directed by the Engineer's Representative, the Engineer's Representative shall be informed accordingly so that he may inspect the completed pit or trench and no excavation shall be filled in or covered with concrete until it has been so inspected and the Contractor has been authorized to proceed with the work.

5. Surplus Material: All surplus excavated materials from excavations not required for refilling shall, if considered suitable by the Engineer's Representative, be deposited in embankments or otherwise disposed of as directed.

6. Excavation Greater than Necessary: Excavation to a depth greater than directed shall be made good by the Contractor at his own expense with concrete Class E.

Excavation to a width greater than necessary in rock shall be made good by the Contractor at his own expense by completely filling the excess volume of excavation with concrete of the same class as the foundation of the structure.

Excavation to a width greater than necessary in material other than rock shall be made good by the Contractor at his own expense and to the satisfaction of the Engineer's Representative by completely filling the excess volume of excavation against the completed foundation either with concrete Class E or if decided by the Engineer's Representative with approved material compacted to a dry density not less than that obtaining in the adjacent soil.

7. Shoring to Excavations: The sides of all excavations shall be adequately shored at all times to the satisfaction of the Engineer's Representative who may require the Contractor to submit details of his proposals for such work, but the submission of such details shall not relieve the Contractor of any responsibility for the safety of the work.

Timber or other shoring materials are to be removed as the work proceeds unless otherwise directed or permitted by the Engineer's Representative.

The Engineer's Representative may direct timbering to be left in trenches or other excavations. Timbering so left in will be measured and paid for as provided in Bill of Quantities, except where in the Engineer's opinion the necessity for leaving in the timber or any other material has arisen from carelessness or neglect on the part of the Contractor.

8. Cribbs and Cofferdams: The Engineer may require that drawings showing the proposed methods of construction of cofferdams and cribs should be submitted for approval, but such approval shall not in any case relieve the Contractor of his responsibility.

Cribs and cofferdams for foundation construction shall be carried out to adequate depths and heights, shall be safely designed and constructed and be made as water tight as is necessary for the proper performance of the work and the internal dimensions shall be such as to give adequate working space for the handling of formwork, the inspection of external faces and to allow pumping from sumps outside the forms.

The length of the material used for the cofferdams and cribs shall be of sufficient length to allow possible lowering of the footings if directed by the Engineer's Representative.

No timber and bracing shall be placed inside cofferdams or cribs that cannot be subsequently removed without damage to the concrete.

The cofferdams and cribs shall be a sufficient protection of fresh concrete against damage from a sudden rising of the stream and an efficient prevention against damage of foundation by erosion.

The cofferdam and crib material used shall be of sufficient length to allow possible lowering of footings as may be directed by the Engineer's Representative.

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless it be done from a suitable sump or well point separated from the concrete work.

Unless otherwise provided the Contractor shall remove all cofferdams, cribs, sheeting and bracing down to the elevation or original ground line or to the new stream bed level in case of channel change or to the top of footings in dry holes. The removal shall be done in such manner as not to damage the finished concrete or any part of the new structure.

9. Foundation Seal: When required on the Drawings or ordered, a concrete foundation seal shall be constructed. The foundation enclosure shall then be pumped out and the balance of the concrete placed in the dry. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure or until five days have elapsed after the last seal concrete has been placed. When weighted cribs are employed and the weight utilized partially to overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal.

10. Water in Excavation: During the time that excavation is being carried out and until the constructional works can suffer no damage from flooding all excavations shall be kept free from water, as specified in Clause R4 15.

Where excavations have to be made and foundations formed below the known ground water level, the Contractor shall submit a full and clear description, supported by such drawings as may be necessary of the methods he proposes to use in respect of each foundation to enable the whole work to be executed in the dry and such measures shall be adopted as the Engineer's Representative approves.

Precaution shall be taken to prevent upward piping of the bottom of excavations either by cutting off sheeting, by lowering the water table or by other means and all such precautions shall be subject to the approval of the Engineer prior to adoption.

11. Refilling of Foundation Pits: Refilling of foundation pits and trenches shall be carried out as soon as possible after the foundations have acquired adequate strength as determined by the Engineer's Representative.

Refilling may only be commenced after structural works within the excavations have been inspected and approved by the Engineer's Representative.

Timber sheeting and other excavation supports shall be carefully removed as the filling proceeds except as otherwise specified or ordered, but the removal of such supports will not relieve the Contractor of his responsibility for the stability of the works.

12. Permeable Backing to Earth Retaining Structures: Where shown on the Drawings or required by the Engineer, back drainage to structures shall be provided. This shall comprise:-

- (i) A minimum thickness of 30cm free draining layer of approved granular material

well graded from 8cm to 0.2mm, or precast porous concrete blocks laid in stretcher bond with dry joints in 22.5cm thick walling.

- (ii) a cut-off of approved clay puddle well worked with water to produce an impervious plastic sealing material or of concrete Class E.
- (iii) weepholes through the structure.

The clay puddle or concrete where required shall be worked well into the material immediately below the lowest set of weepholes so as to provide an effective barrier to the seepage of moisture. The drainage layer shall be lightly compacted, shall be brought up level with the backfilling and shall be maintained as a distinct material therefrom.

13. **Granular Fill to Structures:** When selected granular filling is specified in the Special Specification for Particular Application for compaction against earth retaining structures, it shall consist of well-graded crushed or uncrushed gravel, stone, rock fill, crushed concrete or natural sand or a combination of any of these. It shall not contain unsuitable material as defined in Clause R5 02-4 (iii) nor have a soluble sulphate content exceeding 2.5g per liter when tested in accordance with Test 10 of BS 1377 (1975).

All material shall pass a 150mm sieve and not less than 95 per cent shall pass a 100mm sieve, and at least 90 per cent shall pass a 75mm sieve but not more than 10 per cent shall pass a 0.075mm (No. 200) sieve.

14. **Preservation of Channel:** When foundations or substructures are to be constructed in or adjacent to running streams no excavation shall be done outside cribs, cofferdams, caissons or sheet piling nor shall the natural stream bed adjacent to the structure, be disturbed, without the written permission of the Engineer's Representative. If any open pit excavation or dredging is permitted at the site of the structure before the placement of cribs or cofferdams, the Contractor shall, after the foundations are in place, backfill such excavation to the original surface of the stream bed with material satisfactory to the Engineer's Representative.

The backfilling material shall be of such quality and shall be placed in such manner that it will offer the same resistance to scour as the material removed.

Material deposited within the stream area from foundation excavations shall be removed and the stream bed freed from obstruction thereby. On navigable streams the Contractor shall at all times maintain the depth of water and horizontal clearances required for the passage of water traffic. He shall also furnish and maintain all necessary channel signals and lights during the construction period.

R5 07 Special borrow excavation and borrow material

1. **Description:** Special borrow excavation shall comprise and include pay excavation in borrow pits lying outside and beyond the roadway limits and specifically designated in the special provisions. Special borrow excavation shall not include excavation in borrow areas or ditches which are a part of, continuous to, or adjacent to the road bed cross-section.

The work consists of furnishing all necessary job equipment and labor, carrying out the pay excavation in borrow pits, material haulage and usage for embankment or backfilling. The Contractor shall bear all expenses connected with the opening and operating of borrow pits.

2. **Borrow Areas:** Borrow material for fill shall be obtained from the borrow areas designated on the Drawings or from the areas selected by the Contractor, subject to the approval or the Engineer's Representative.

No borrow pit shall be opened until the material has been sampled in depth and approved as suitable and written approval given by the Engineer's Representative for the commencement or the excavation. Rock and unsuitable material for filling shall not be excavated, or if excavated by the Contractor, shall be re-deposited in the pit as instructed and shall not be measured.

3. **Right to Procure Material:** The employer will compensate the owners for all materials taken from borrow areas designated on the Drawings. Should the Contractor select to use any borrow area not designated on the Drawings, he shall obtain from the owners the right to procure materials from such source and shall pay all royalty and/or other charges and expenses involved.

4. **Haulage Roads:** Roads for hauling the soil out of the borrow area should be provided by the Contractor. These works will not be paid as an extra payment.

R5 08 Embankment in place

1. **Description:** Material for Embankment in Place shall be obtained from borrow areas within the Right of Way as indicated on the Drawings or from areas selected by the Contractor, subject to the approval of the Engineer's Representative.

When borrow areas are permitted within the Right of Way they should be confined to the outer 10 meters of the Right of Way and be of regular shape, continuous over the complete length where borrow is permitted and neatly finished. The depth will be limited to 1.5 meters or to groundwater level whichever is the less. All borrow pits whether within the Right of Way or not must be self draining to prevent the accumulation of stagnant water.

All work on borrow areas is to be to the approval of the Engineer's Representative.

2. **Material:** All material for the embankment shall be subject to the approval of the Engineer's Representative. Any unsuitable material deposited in the works shall be removed and replaced by acceptable material by the Contractor at his own expense.

Material unsuitable for the embankment encountered in the designated borrow area may be used as required to widen uniformly embankments, flatten slopes, to fill low places in the right of way or for other purposes as the Engineer may direct or may be completely rejected. Such unsuitable material shall be measured in its final location and shall be paid for at the price tendered for Embankment in Place.

Overhaul will not be allowed and no direct payment will be made for any losses of material which may result from shrinkage, compaction, foundation settlement, erosion, leakage or any other cause.

R5 09 General excavation

1. **Description:** General excavation shall comprise and include all excavation other than drainage excavation, excavation for structures, special borrow excavation and the excavation for Embankment in Place. General excavation shall also be understood to include cut

ditches, borrow ditches and other ditches in the road bed section or shown on the typical road bed cross-section.

2. Performing the Excavation:

- (i) Prior to beginning the excavation work it is necessary to carry out all clearing and grubbing in accordance with Section R2.
- (ii) Excavation of every description within the grading limits of the project shall be completed to the lines and grades shown on the Drawings or as directed by the Engineer's Representative, including benching for embankments as specified in Clauses R5 11-1 (v) & R5 11-1 (vi).
- (iii) Excavation shall proceed in such sequence and manner and shall be so correlated with other phases of construction that suitable conditions for the maximum drainage discharge will be provided at all times. Ditches shall be maintained so as to ensure proper drainage at all times.

3. Excavation to Formation Level:

- (i) The excavation shall be carried out so as to avoid any undercutting and consequent instability of the finished side slope.
- (ii) Should the slopes of any cutting be excavated beyond that required, the Contractor shall make good each affected area in a manner satisfactory to the Engineer without additional charge.
- (iii) Where excavation reveals a combination of suitable and unsuitable materials the Contractor shall, unless otherwise agreed by the Engineer's Representative, carry out the excavation in such a manner that the suitable materials are excavated separately for use in the Works without contamination by the unsuitable materials. The unsuitable materials shall be disposed of in accordance with Clause R504-1.
- (iv) If with the agreement of the Engineer's Representative any suitable material excavated from within the site is taken by the Contractor for his own use, for instance for producing aggregates for concrete, crushed stone base or sub-base, for surfacing or for haul roads or for any other purpose in or connected with the Works, sufficient suitable filling material to occupy, after compaction, a volume corresponding to that which the excavated material would have occupied in embankment, shall be provided by the Contractor from his own resources free of charge.
- (v) No suitable excavated material shall be dumped or run to spoil, except with the written permission of the Engineer's Representative, if the Contractor can show to his satisfaction that this procedure would be economically advantageous.
- (vi) Material used for haul roads shall not be re-used in embankment or elsewhere without the permission of the Engineer's Representative.
- (vii) Excavation shall be discontinued when climatic conditions prevent the placing of the excavated material in embankment in accordance with the Specification.

4. Dressing Formation Level in Rock Cuttings: Where rock or hard material is encountered at formation level in cuttings, the Contractor shall dress the rock surface in a manner to suit the construction to be superimposed.

The rock shall be trimmed approximately to formation level so that the resultant surface

is sufficiently smooth for the satisfactory operation of spreading equipment. Any over break or excess excavation shall be made good at the Contractor's expense in the material to be superimposed and additional compaction effort shall be applied to the satisfaction of the Engineer's Representative without extra payment. If the over break is irregular or exceeds 8cm. the Engineer's Representative may require the excess excavation to be made good with concrete Class E at the Contractor's expense.

5. Improvement of Subgrade in Cuttings:

- (i) Where in cuttings the material encountered in the subgrade at or near formation level is in the opinion of the Engineer's Representative unsuitable, this material shall be excavated and disposed of as the Engineer's Representative may direct and replaced with approved filling material compacted as specified in Clause R5 11.
- (ii) Where the material is suitable, but insufficiently compacted, such material shall be removed, replaced in layers as necessary and compacted as specified for embankments and the Contractor shall provide additional approved filling material that may be needed up to formation level due to shrinkage of material compacted.
- (iii) Such work as is directed to authorized outlines will be paid for where itemized In the Bill of Quantities. Any excess excavation beyond that ordered will not be paid for, but the void shall be filled in and compacted as specified at Contractor's expense.

R5 10. Control and disposal of excavated materials

The methods used in making road bed excavation shall be such as will not shatter or loosen excavation slopes, but will leave the slopes accurately and smoothly trimmed. As far as practicable, the materials to be excavated shall be loosened by means of rooters and scarifiers or shall be excavated without previous loosening. Such as must be done shall be controlled in a manner which will avoid possible shattering or loosening of materials behind the slope lines to which the excavations are to be made, as directed by the Engineer's Representative. Excavated materials suitable for use in embankment construction and backfilling shall be used in the construction of embankments and in filling and backfilling work as indicated on the Drawings or directed by the Engineer's Representative.

Should the quantities of excavated materials be greater than required to construct all the embankments or other required filling and backfilling, the excess material shall be used to widen embankments uniformly or shall be otherwise disposed of as the Engineer's Representative may direct. When excess materials are used to widen embankments uniformly, the limits between which the embankments are to be widened with any given quantity of excess materials shall be as the Engineer's Representative directs. Excess materials not used in embankment widening shall be deposited at such locations and to such lines, grades and cross-sections as the Engineer's Representative may direct. The excavation and disposition of filling material for each, or part of each, embankment shall be spread and compacted, in separate and clearly defined areas, for each particular kind of material. as directed by the Engineer's Representative.

Excavation shall not be carried out when conditions prevent the placing of the excavated materials at the specific locations at which their use is desired by the Engineer's Representative.

Any material unsuitable for use in embankment construction and backfilling shall be

disposed of in such manner as the Engineer's Representative may direct. Excavated materials deposited contrary to the requirements above stated and without the consent of the Engineer's Representative, shall be picked up and re-deposited as the Engineer's Representative directs and at the Contractor's expense.

R5 11 Embankment constructions

1. Embankment Area Preparation:

- (i) Prior to placing the filling, the grubbing-up and clearing shall be performed within the given area according to Section R2, the unsuitable material shall be removed and any other work shall be completed in accordance with the Clause R5 04.
- (ii) Unit Dry Weight of natural ground shall comply with minimum 88% of that determined by AASHTO T180- 74 (Modified AASHTO Compaction Test) up to the depth 25cm, otherwise the natural ground shall be compacted and drained whenever needed to achieve this percentage at no extra cost to the employer.
- (iii) Where the surface contains holes, ditches, gullies, etc., such depressions shall be backfilled with approved material compacted to the same density as that of the surrounding material.

Where the ground has been ploughed, ripped or otherwise loosened, it shall be shaped and compacted as specified below in Clause R5 11-4.

- (iv) Where the area of deposited filling is on an existing pavement, concrete, rock or other hard material, including natural densely compacted soils without vegetation, the area shall be scarified to a depth of at least 15cm and finely broken up in order that the fill material may be well bonded with the old surface.

Where the height of the new embankment above the existing ground is less than 50cm the scarified material shall be shaped and compacted as specified to the same minimum density as specified for the new embankment.

- (v) Where an embankment is on sloping ground of at least 1 in 4 slope, or at such other locations as the Engineer's Representative may direct, the surface of existing ground shall be benched (in nearly horizontal steps or trenched) as shown on the Drawings, including if necessary any under-draining of the affected part of the Site.

The benching or trenches shall be kept free of water in accordance with Clause R5 06-10.

- (vi) Where the new embankment will envelop an old embankment on one or both sides, the side slopes of the old embankment shall be benched as directed by the Engineer's Representative, and the new fill brought up in successive layers to the level of the old embankment before the height is increased.

In such areas the till material and the excavation from the benching shall be deposited and compacted as specified below in Clause R5 11-4.

- (vii) Where an embankment is to be placed over an existing pavement, concrete, rock, etc. the old pavement, etc. shall be scarified as Clause R5 11-1(iv) and completely broken up so that all cleavage planes are destroyed and fill material will bond

properly.

Where the old pavement is of the rigid type and the depth of new embankment is less than one meter, the old pavement shall be completely removed and disposed of as directed by the Engineer's Representative.

2. Field Compaction Trials:

- (i) The Contractor shall put forward in writing to the Engineer for his approval a list of the plant he proposes to use for compaction of filling in embankment and elsewhere where required.
- (ii) The precise manner in which the earthworks are to be compacted shall be the subject of field compaction trials to establish the type, sequence and numbers of passes of the compaction plant necessary to obtain the degree of compaction specified hereafter, the optimum moisture content associated with such plant and the thickness of layer that may be effectively compacted.
- (iii) An area within the site selected by the Engineer's Representative and approximately 20m by 20m in plan shall be stripped of any surface growth and then excavated as required by the Engineer's Representative to a depth not exceeding 0.5m. The Contractor shall then bring in the material under trial and carry out the trial with the approved plant to establish the criteria set out above. On completion of the trial the Contractor shall reinstate the area and leave it generally tidy.
- (iv) The field compaction trial shall proceed until such time as both the Engineer's Representative and the Contractor are agreed as to the procedure necessary to obtain the required degree of compaction in the embankments as specified. The agreed procedure embracing the type, sequence and number of passes of the plant required to compact a layer of the agreed thickness before compaction and the limits within the moisture content of the soil shall be at the time of compaction shall be recorded and shall thereafter form the basis of the field control of the compaction plant on that material.
- (v) A field compaction trial shall be carried out on each major soil type as determined by the Engineer's Representative.

3. Construction of Embankments:

- (i) Embankments shall be constructed to the lines and grades as shown on the Drawings or to the outlines specified by the Engineer.
- (ii) The Contractor shall make allowance for construction, if any, of embankment foundation and for compaction and shrinkage of fill material, so that on completion of the earthworks the profile of the embankment is as required.
- (iii) Embankments shall be formed of suitable material, other than that described as unsuitable in Clause R5 02-4 and shall be constructed and compacted as specified below in Clause R5 11-4.
- (iv) Embankments shall be constructed of material spread in successive layers for compaction, each layer extending over the full width of the embankment at the height of the layer and the Contractor shall ensure that the required compaction is obtained throughout each layer, not omitting the material which after trimming will form the side slopes. Rolling shall begin at the edge of the fill and progress toward the centre line overlapping on successive trips by at least one half the width

of the roller unit. On superelevated curves rolling shall begin at the low side and progress towards the high side.

- (v) Where materials of appreciably different characteristics are to be deposited in embankments such materials shall be spread in separate layers, each layer composed of only one type of material. Layers shall be reasonably leveled, or if directed, at such crossfalls as will shed storm water and prevent ponding.

Fill material shall not be stockpiled on embankments and if in the opinion of the Engineer's Representative the plant used for depositing the material does not spread the material uniformly in a satisfactory manner, the Contractor shall employ plant to spread and grade layers for compaction.

- (vi) Earthmoving plant shall be positively controlled by the Contractor and routed over the full width of the embankment so as to ensure a degree of uniform compaction from such plant.

The depth of each layer of filling shall suit the compaction plant and the compaction procedure evaluated in the Field Compaction Trials, unless otherwise directed by the Engineer's Representative.

- (vii) Any hard material that is not broken down by the passage of the compacting plant shall either not be accepted by the Contractor for filling material or be broken down by discing, harrowing or other means into individual pieces not exceeding in any dimension half the depth of the compacted layer.
- (viii) Exceptionally, where in the opinion of the Engineer's Representative the material available for forming the embankment is predominantly of rock fragments of such size that the material could not be placed in layers for compaction as specified above, nor could reasonably be broken down, the embankment or part thereof as directed may be formed as a rock fill in the following manner and compacted as specified in Clause R5 11-4.

Rock used in rock fill embankments shall be of such size that it can be deposited in layers so as to suit the conditions evaluated in the field compaction trials, unless otherwise directed by the Engineer's Representative.

The material shall be spread and leveled by a heavy crawler tractor weighing not less than 15 tons. Each layer shall consist of reasonably well graded rock and all voids shall be filled with broken fragments or with other selected material for the compaction of the layer. Large lumps of material shall not be concentrated in "nests", but shall be distributed and well packed round with finer material. This is particularly important if non-durable rock is used.

- (ix) Rockfill shall not be permitted within 40cm of formation level. Where materials of different characteristics are readily available, those of relatively high bearing capacity shall be placed in the topmost 40cm below formation.
- (x) No rock fragments more than 12cm in any dimension shall be placed within 40cm of formation level. No logs, stumps, scrub or other perishable material shall be deposited anywhere within the embankment.
- (xi) The maximum size of rock fragments incorporated in the embankment must not exceed 2/3 (two thirds) of the agreed layer thickness used for compaction and in no way exceeds 0.05 cu. m in total size.

4. Compaction of Earthworks:

- (i) Work on compaction of materials in embankments shall only be carried out when the material has a moisture content within the limits agreed in the field compaction trials. The Contractor shall, if required, adjust the moisture content of material spread without extra charge. Should the material be too dry, the required amount of water shall be applied uniformly and thoroughly mixed in the soil by blading, discing or harrowing until a uniform and satisfactory moisture content is obtained throughout the depth of the layer. Should the material be too wet, it shall be aerated by blading, discing or harrowing until the moisture content is satisfactory. The Contractor shall conserve the moisture content of material excavated when this is close to the optimum moisture content and such material shall not be stockpiled or double handled, but shall be spread and compacted without delay. Allowance shall be made for evaporation. for instance in excessively hot weather, by the addition of extra moisture so that compaction may be carried out satisfactorily.

The Engineer's Representative may order cessation of the work or further field compaction trials if the required degree of compaction is not obtained.

- (ii) The degree of compaction shall be measured in each layer at least twice every 2000cm² for comparison, or more frequently as required by the Engineer's Representative.

The determination of the dry density achieved shall be performed in accordance with AASHTO T191-61 or T205-64 (cone method or balloon method), or other suitable method subject to the approval of the Engineer's Representative, and compared with the maximum dry density as determined by AASHTO T150-74 (Modified AASHTO Compaction Test). The results so measured shall be reported in writing to the Engineer's Representative daily or when required.

No compacted layer shall be covered until approved by the Engineer's Representative who may require a compacted layer to be scarified to a shallow depth to ensure bonding with the layer to be superimposed.

- (iii) Rolling of earth embankments shall be made at the percentages indicated in the table of the maximum density for the modified compaction. The Contractor is advised to make trial sections to determine the earth layers, method of rolling and machinery required for achieving such percentages.

The degree of compaction required shall comply with the following minimum percentage of Unit Dry Weight as determined by AASHTO T180-74 (Modified AASHTO Compaction Test) unless otherwise directed by the Engineer's Representative.

- (a) All structural and/or drainage excavation which is to be backfilled and/or all backfill behind and around the structures, etc, 95%.
- (b) Subgrade soil compaction (the active soil layer) 30cm below the formation in all parts of the embankment and cut areas throughout the whole length and width of section shall be not less than 95%, drainage whenever needed and compaction to achieve this percentage shall be carried out by contractor at no extra cost to the employer. The minimum CBR shall be 4% at 95% of the maximum density established according to AASHTO T 180. Liquid limit and plasticity index should be less than 55% and 30% respectively, otherwise the soil shall not be regarded as

suitable to be used for subgrade.

Soils with a maximum dry unit weight in modified compaction of less than 1.70g/cm^3 are considered unsuitable for use in the top 300mm. Soil layer immediately below the surface of the subgrade and has the forementioned density shall be replaced with suitable soil or granular material.

(c) Requirements for embankment soil compaction,

All portions of the soil embankment throughout the total width and depth on the cross-section shall be compacted as given below.

1. Subgrade and shoulders shall be compacted to a minimum of 95% modified AASHTO dry density. Embankment with heights less than 2m (excluding subgrade) shall be compacted to a minimum of 94% modified AASHTO dry density. For embankments with higher heights, the layers in the upper 2m (excluding subgrade) shall be compacted to a minimum of 94% modified AASHTO and the lower layers shall be compacted to a minimum of 93% modified AASHTO.

As side slopes are subject to weather, special care should be given to the compaction of the layer edges forming them.

- (iv) The depth of compacted layer is the height by which an embankment is raised by each successive compacted layer.
- (v) Each layer of rock used as rock fill in embankments shall be spread and leveled in accordance with Clause R5 11-3 and systematically compacted by at least 12 passes of a towed vibratory roller with a static load per cm width of roll of at least 18kg or a grid roller with a load per cm width of roll of at least 80kg or other approved plant. Where, however, the rock contains sufficient soft material for satisfactory compaction to the requirements for well-graded granular soil the fill shall be compacted to such latter requirements, When materials of widely divergent characteristics are used in embankments and fill areas they shall be spread and compacted in separate clearly defined areas in such a manner as to comply with the requirements of Clause R5 11-3, If more than one class of material is being used in such a way that it is not practicable to define the areas in which each class occurs, compaction plant shall be operated as if only the material which requires the greatest compactive effort is being compacted.

The number of passes is the number of times that each point on the surface of the layer being compacted has been traversed by the item of compaction plant.

- (vi) The thickness of the layers and the necessary number of passes or blows of compacting means shall suit the results of the Field Compaction Trial.

The degree of compaction shall be controlled by the number of passes or blows as indicated by the Field Compaction Trial or otherwise as directed by the Engineer's Representative. Compaction shall continue until negligible movement occurs under heavy wheel load.

- (vii) For rock fill, the number of passes with the equipment and layer thickness chosen shall be sufficient when the settlement of the fill during the nth pass of the compaction roller amounts to maximum 5% (five percent) of the settlement up to the nth pass. Rock fill shall always be compacted by at least 12 passes of a compaction roller as specified in clause R5 11 4(V) no matter the results of the trial compaction tests. The specified maximum settlement shall only be used to

determine the necessary number of passes if 12 passes are not sufficient.

5. Equipment:

- (i) The Contractor shall provide sufficient equipment in numbers and capacity of all types available to ensure the completion of the work according to the Specification and within the Contract time.

All equipment used in the performance of the work shall comply with the definitions and requirements in (ii) below and shall be subject to the approval of the Engineer or the Engineer's Representative. It shall be maintained in satisfactory working condition at all times and sufficient reserve equipment shall be readily available to maintain the proper continuity of all earthwork operations under practicable working conditions.

- (ii) The following definitions and equipment requirements shall be used as a guide for assessing and quoting the comparative performance of various compacting equipment during Field Compaction Trials.

In defining the number of passes of pneumatic-tired rollers to meet the compaction requirements, the effective width shall be the sum of the widths of the individual wheel tracks together with the sum of spacing between the wheel tracks, provided each spacing does not exceed 23cm. Where the spacing exceed 23cm the assessed effective width shall be the sum of the widths of the individual wheel tracks.

The load per cm width is the total weight on the roll divided by the total roll width. Where a smooth-wheeled roller has more than one axle the machine will be assessed on the basis of the axle giving the highest value of load per cm width.

For pneumatic-tired rollers, the wheel load is the total weight of the roller divided by the number of wheels.

Vibratory rollers are self-propelled or towed rollers having means of applying mechanical vibration to one or more rolls.

- (a) The requirements for vibratory rollers are based on the use of the lowest gear on a self, propelled machine and a towing speed of 1.6 to 2.4km/h for a towed machine. If higher gears or speeds are used an increased number of passes shall be provided in proportion to the increase in speed of travel.
- (b) Vibratory rollers operating without their vibration mechanism in use will be classified as smooth-wheeled rollers.
- (c) Vibratory rollers shall be operated with their vibration mechanism operating only at the frequency of vibration recommended by the manufacturers. All such rollers shall be equipped with a device automatically indicating the frequency at which the mechanism is operating.

Vibrating-plate compactors are machines having a base-plate to which is attached a source of vibration consisting of one or two eccentrically-weighted shafts.

- (d) The static pressure under the plate of a vibrating-plate compactor is calculated by dividing the total weight in kg of the machine in working order by the area in square millimeters in contact with compacted soil.
- (e) Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at

traveling speeds of less than 50m per minute, but if higher speeds are necessary the number of passes shall be increased in proportion to the increase in speed of travel.

Vibro-tampers are machines in which an engine-driven reciprocating mechanism acts on a spring system, through which oscillations are set up in a base-plate.

Power rammers are machines which are actuated by explosions in an internal combustion cylinder, each explosion being controlled manually by the operator.

- (f) In the case of power rammers one pass will be considered as made when the compacting shoe has made one strike on the area in question.

Where combinations of different types of categories of plant are used, the compaction requirements shall be:

- (g) The depth of layer shall be that for the type of plant requiring the least depth of layer; and
 (h) The number of passes shall be that for the type of plant requiring the greatest number of passes.

However, where the Contractor uses a lighter type of plant to provide some preliminary compaction only to assist the use of heavier plant, this shall be disregarded in assessing the above requirements.

Particular care is necessary in the use of compacting equipment in uniformly graded materials. In the case of vibratory rollers having a static load per cm width of vibratory rollers of less than 12kg, self propelled rollers are unsuitable and such rollers should be towed by track laying tractors. The use of smooth wheeled rollers, grid rollers and pneumatic tired rollers for compacting uniformly-graded materials is also limited to low loads per cm width or wheel loads not exceeding 1½ tones.

6. Sampling and Testing: The soils shall be systematically sampled and tested in accordance with the following AASHTO Standards or BS1377 (1975).

(i) Classification Tests	AASHTO	BS1377
Preparation of test sampler Dry	T87-72	Cause 1,5
Preparation of test sampler Wet	T146-49	
Mechanical Analysis	T88-77	Test 7
Specific Gravity	T100-74	Test 6
Atterberg Limits		
Liquid Limit	T89-68	Test 2
Plastic Limit	T90-70	Test 3
Shrinkage Factors	T92-68	Test 5
Moisture Content	-	Test 1
(ii) Compaction Tests		
Dry Density (2· 5kg rammer)	T99-74	Test 12

Modified AASHTO compaction (4.5kg rammer)	T180-74	Test 13
Dry Density (vibrating hammer)	-	Test 14
Density in Place		
Drive Cylinder	T204-64 (1974)	Test 15D
Sand Replacement	TI91-61(1974)	Test 15
Ballast Method	T205	
California Bearing Ratio.	TI93-72	Test 16

Tests shall be made as often as deemed necessary by the Engineer's Representative to ensure compliance with the requirements of this Section of the Specification. Testing will be performed by the Employer without cost to the Contractor.

Tests for compaction shall be on a random basis and cover the entire width after section. Testing of any layer of construction will be deemed acceptable providing 8 out of 10 consecutive tests are equal to or in excess of the minimum and the remaining tests do not fall below the minimum by more than 2%.

7. Embankments at Approaches to Bridges: To avoid interference with the construction of bridge abutments and wing walls the Contractor shall, at points to be determined by the Engineer's Representative, suspend work on embankments and/or cuttings forming the approaches to such structures until such time as the construction of the latter is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the bridge works.

The Contractor shall allow in his rates for Earthworks entered in the Bill of Quantities, for any extra cost which may arise from such suspension.

8. Reinstatement of Damage by Rain: Throughout the currency of the Contract all damage to completed earthworks attributable to rain and rainfall run-off or to any other cause shall be made good by the Contractor within 24 hours of such damage occurring without additional cost to the employer.

9. Slips, Subsidence and Overbreaks: In the event of any slip, slide or subsidence taking place in the earthworks extending beyond the required profile of embankment, the Contractor shall dispose of the material in the slip and make good as required by the Engineer's Representative. The classification of material from slips or slides will be in accordance with its condition at the time of removal irrespective of its prior condition.

R5 12 Grade and alignment control

1. The entire work shall be constructed to the exact position and elevation in conformity to the lines and grades shown on the Drawings or as directed by the Engineer's Representative. The Contractor will be given control line and grade at various intervals throughout the work ; he must provide his own men and instruments for determining alignment, elevation and position of all construction between such points, subject to the check and Correction by the Engineer's Representative. The Contractor shall keep the Engineer's Representative informed a reasonable time in advance of the time and place he intends to do work, in order that control lines and grade may be furnished and the necessary measurements made for record and payment with the least inconvenience to the Engineer's Representative and delay to the Contractor. The Contractor shall comply with Clause R I 04. Any changes in the stakes and marks caused by the development of construction shall not be made the basis of a claim for payment. Any stakes or marks destroyed by the Contractor shall be replaced by him at his own expense.

2. Tolerances in Surface Levels: The finished earthworks surface unevenness when tested by a 3m straight edge, by taking the measurement at the deepest point between two contact points of the straight edge, shall comply with the following surface level tolerances.

Formation: - 3cm.

Side slopes : - 10cm. The sides lopes of rock cuttings need only be trimmed to give an average side slope as specified; the finished appearance of the rock face will vary to suit the character of the rock.

Verges or Shoulders: - 3cm.

The Contractor shall inform the Engineer's Representative in a reasonable time in advance, of the time and place of work, so as to ensure that the taking of measurements, is of the minimum inconvenience to the Engineer's Representative and minimum delay for the Contractor.

R5 13 Overhaul

Overhaul will consist of performing all operations necessary for the authorized transportation of fill material more than a distance of five hundred meters from the centre of mass of the material in its original position to the centre of mass of the resulting embankment.

R5 14 Pitching

Where shown on the Drawings or directed by the Engineer's Representative hand-set pitching laid dry or in 1:3 cement mortar shall be placed to stabilize slopes or as a protection against water or other erosion to form a flat or curved surface as required by the Engineer's Representative.

The stones shall comprise good hard durable broken boulders or pieces of rock of a type approved by the Engineer's Representative, roughly squared and shaped, set on their edges with their longest dimension at right angles to the flow of water. They shall be securely bedded, breaking bond, closely packed with any interstices locked and filled by selected stone spalls hammered in. Pitching shall be laid on a bed of approved granular material of 80mm thickness.

The depth of the stones and their weight shall generally not be less than

- (a) 22cm and 25kg for heavy pitching to culvert ends and approaches, wadi diversions, protection of structures, revetment to slopes and where directed,
- (b) 17cm and 10kg for lighter pitching where directed to ditches, beams, etc.

The ends of pitched areas shall be protected from undermining by the use of edge stones at least twice the general size and weight set on end. In large or sloped areas of pitching, keystones shall be provided at the rate of one per square meter, at least one and a half times the general size and weight, set on end.

The pitching to the batters of the earthworks and diversions of waterways shall be carried down in trench to such a depth as will ensure a sound footing for the lowest course; subsequent to pitching, the trench shall be backfilled to normal ground level with approved, well compacted material.

Pitching laid in cement mortar shall be laid in panels with weepholes, the joints between

the panels being approximately 2cm in thickness and extending the full depth of the pitching; the joints shall be filled with a sand-bitumen mixture consisting of approximately one part by weight of bitumen heated as necessary to two parts by weight of a clean sharp sand. The dimensions of the panels shall be approximately two meters square, but the precise dimension in any instance and the spacing of the weepholes shall be as required by the Engineer. In laying the pitching the lines of the panel joints shall be picked out with a straight fillet laid on the face of the earthworks and the stones set up carefully to the edge of the fillet. Subsequent to laying the pitching, the fillet shall be removed and the joint caulked with the sand-bitumen mixture as above.

R5 15 Maintenance

After completion the roadway (all construction items within the right of way) shall be continuously maintained by the Contractor to the satisfaction of the Engineer and to the required grades and cross-sections, until the project is accepted.

R5 16 Measurement

1. Salt Stripping: The unit of measurement for salt stripping shall be the cubic meter.

The number of cubic meters for payment shall be computed by the average end area method from cross-sections taken by the Engineer's Representative, before and after stripping.

Measurement will not include stripping of any description from excavation or borrow areas, which will be paid for as Excavation.

2. Removal of Old Pavement: The unit of measurement for the removal of old pavement shall be the square meter. The number of square meters for payment shall be the area actually removed: it shall not include the area of pavement scarified, but left in place.

3. Excavation: The unit of measurement for excavation shall be the cubic meter.

The number of cubic meters of excavation shall be computed by the average end area method from cross-sections taken by the Engineer's Representative before commencing and after completing the required excavation.

The number of cubic meters for payment shall be the cubic meters of material removed from all excavation and borrow areas, including:

Material which is acceptable, utilized in backfill or embankment construction as herein specified, material from drainage excavation and structural excavation, material used in shoulder construction as required in other sections of the Specification, salt stripping from excavation or borrow areas and authorized waste material.

Measurement will not include, the cubic meters of material excavated beyond the net cross-section line shown on the Drawings unless authorized by the Engineer, the cubic meters of excavated material which is used for any purpose other than that indicated on the Drawings unless directed by the Engineer, the cubic meters of salt stripping from the embankment area, or the cubic meters of material removed prior to the original cross-section measurement.

4. Overhaul: The unit of measurement for payment will be the "meter-station", The

number of overhaul units to be paid for will be the product of the overhaul distance expressed in stations multiplied by the quantity of excavation in cubic meters and shall be expressed in "meter-stations".

A "station" will be one hundred meters.

Haul distances of five hundred meters, or less, shall be designated as "free haul" for which no overhaul payment will be made.

The limit of free haul will be determined by fixing on the profile two points five hundred meters apart, one on each side of the neutral grade point, selected in such a way that the included quantities of excavation will balance the included quantities of embankment.

All material hauled beyond the free haul limit of five hundred meters will be overhaul and shall be estimated and paid for on the basis of the following method of computations:

- (i) All material, whether roadway or borrow excavation within the limits of five hundred meters will be eliminated from further consideration.
- (ii) The overhaul distance will be the distance between the centre of gravity of the remaining mass of excavation and the centre of gravity of the resulting embankment, less five hundred meters, free haul.
- (iii) The amount of overhaul to be paid for shall be obtained by multiplying the overhaul distance in stations, measured along the centre line of the improvement, by the quantity of the remaining mass of excavation, computed by the average end area method from cross-sections taken by the Engineer's Representative immediately after salt stripping has been performed and after completing the necessary excavation.

If the material is to be obtained from borrow pits, or is to be wasted in spoil areas, it shall be hauled over the shortest practical route, which shall be designated by the Engineer's Representative before hauling begins from any source of supply. The overhaul distance for all material hauled over five hundred meters shall be the distance from the centre of gravity of the borrow pit to the centre of gravity in place on the road, or from the excavation in the roadway to spoil bank, at the point designated by the Engineer's Representative, less five hundred meters. The overhauled material distance shall be the total distance as provided above but less the free-haul distance of five hundred meters, regardless of the route used by the Contractor in material hauling from pits to spoil areas or from stripping points to the place where material is to be used in the road.

5. **Embankment in Place:** The quantity of embankment in place to be paid for under Clause R5 08 will be the number of cubic meters of material measured in its final compacted position, placed and disposed of as required by the Drawings and Specification within the limits shown on the Drawings unless otherwise ordered in writing by the Engineer.

R5 17 Payment

1. **Salt Stripping:** The cubic meters of salt stripping, computed as specified in Clause R5 16-1, hereof, will be paid for at the price tendered per cubic meter of salt stripping, which payment shall constitute all compensation for furnishing all equipment, labor and incidentals necessary to complete the stripping and removal of salts material from the embankment area.
2. **Removal of Old Pavement:** The square meters of old pavement removed, measured as specified in Clause R5 16-2, will be paid for at the price tendered for removal of old pavement, which payment shall constitute full compensation for furnishing all equipment, labor and incidentals necessary to complete the removal of old pavement in accordance with this section of the Specification and the applicable Drawings.
3. **Excavation for Structures:** The quantity of excavation for structures for which payment will be made, will be the quantity actually removed, but it shall not exceed the volume in place within vertical planes coincident with the outside of the net lines of the footings, from the surface of the ground as it exists at the time when the foundation excavation is started, but not higher than the ground level immediately prior to the commencement of the work to the elevation shown on the Drawings or to such elevation as the Engineer may direct. The Contractor shall not be entitled to payment in respect of excavation to any greater extent, whether horizontally or vertically, than is necessary to receive the structure for which the excavation is intended.

Any work connected with keeping the excavation dry, with any bailing or pumping, timbering, shoring, sheet piling, cofferdams, caisson or with other special appliance for supporting of sides and with filling, ramming and disposal of surplus materials shall be included in the rates for excavation and will not be paid for under separate rates in any other part of the Bill of Quantities,
4. **Excavation:** The volume of excavation of the various classes as given in Clause R5 02-3, measured as specified in Clause R5 16-3, hereof, will be paid for at the price tendered per cubic meter of excavation, which payment shall constitute full compensation for: maintaining grade and alignment control stakes, required excavation of all types, including Drainage Excavation, Special Borrow Excavation, General Excavation, Salt Stripping. opening and operating borrow pits, preparation of the embankment area and construction of the embankment, including backfilling around structures, bailing or pumping water, close timbering, sheet piling, cofferdams, caissons or other special appliance for supporting sides of trenches or pits in Drainage excavation and Excavation for Structures. Maintenance of the completed work until final acceptance and furnishing of all other materials, including the necessary water for compaction, labor and incidentals necessary to complete the work required in accordance with this section of the Specification and the applicable Drawings.
5. **Overhaul:** The number of meter-stations, computed as specified in Clause R5 16-4, will be paid for at the price tendered in the Bill of Quantities per meter-station, which payment will constitute full compensation for all equipment, labor and incidentals required for transporting fill in excess of 500m.

If the Drawings or Bill of Quantities show no overhaul quantities or a note that overhaul will not be paid for as a separate item, then the costs of all overhaul will be considered as included in and completely compensated for by the prices tendered for other items of

work included in the Bill of Quantities.

6. **Embankment in Place:** The price tendered for this item shall include the cost of furnishing all labor, material and equipment, including water required for compaction and all other things necessary to complete the work of constructing the Embankment in Place including ramp and shoulder construction.
7. **Shrinking and Swelling:** In measuring all excavations the quantities shall be regarded as the net cubic content of the void formed by the removal of the material excavated in accordance with the Specifications and Drawings, no allowance being made for shrinking, bulking, swelling or settlement.

Note : The volume of borrow material is obtained by deducting the total volume of suitable fill available from excavations within the Works from the total volume of fill required to complete the embankments. In all cases the net cubic content is used without allowance for shrinking, swelling, bulking or settlement.