JKR/SPJ/2020-S2
JKR 20400-0237-20

KERAJAAN MALAYSIA
JABATAN KERJA RAYA MALAYSIA

STANDARD SPECIFICATION FOR ROAD WORKS

Section 2: Earthworks

ISBN 978-967-2284-24-6

KETUA PENGARAH KERJA RAYA
JABATAN KERJA RAYA MALAYSIA
JALAN SULTAN SALAHUDDIN,
50582 KUALA LUMPUR.

FOREWORD

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

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

This document "Standard Specification for Road Works - Section 2: Earthworks (JKR/SPJ/2020-S2)" is a part of series of improved specifications in the Standard Specification for Road Works. The compilation of this document was carried out through many discussions by the technical committee members. Additionally, it has been presented at a technical workshop held on February 2019. Feedbacks and comments received had been carefully considered and incorporated in the Specification where appropriate as well as considering the ambiguities and difficulties that arise in the previous version.

In the new version of this Specification, it has also considered the use of two newly introduced Specifications, namely "Standard Specification for Road Works - Section 18: Soil Stabilisation (JKR/SPJ/2018-S18)" and "Standard Specification for Road Works - Section 20: Ground Improvement (JKR/SPJ/2020-S20)", where both should be read together with this Specification where applicable.

This Specification also had been presented in the *Mesyuarat Teknikal Cawangan Jalan* Bil.6/2019 on 23rd September 2019, approved in *Mesyuarat Jawatankuasa Spesifikasi Piawai JKR bagi Kerja-kerja Jalan Bil. 2/2020* on 13th March 2020, and finally presented in the *Mesyuarat Pengarah Bil. 04/2020* on 17th August 2020.

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

Published by: -

Cawangan Jalan,
Ibu Pejabat Jabatan Kerja Raya Malaysia
Tingkat 21, Menara PJD,
No. 50, Jalan Tun Razak,
50400 Kuala Lumpur.
Email: ussj.jkr@1govuc.gov.my

September 2020

ACKNOWLEDGEMENT

This **"Standard Specification for Road Works - Section 2: Earthworks"** has been prepared by a technical committee comprising of the following members:

Committee Members:

Ir. Ismail Bin Mohamad (Chairman)	Caw. Kejuruteraan Geoteknik, JKR
Ir. Edayu Binti Saleh @ Aman	Caw. Kejuruteraan Geoteknik, JKR
Ir. Som Pong a/l Pichan	Caw. Kejuruteraan Geoteknik, JKR
Ir. Eng Boon Cheng	Caw. Kejuruteraan Geoteknik, JKR
En. Zulkifli Bin Ismail	Caw. Kejuruteraan Geoteknik, JKR
Ir. Eow Thien Ewe	Caw. Jalan, JKR
Ir. Eka Kusmawati Binti Suparmanto	Caw. Kejuruteraan Geoteknik, JKR
En. Hisham Bin Ahmad	Caw. Kejuruteraan Geoteknik, JKR
En. Faizul Nizam bin Mohd Nan	Caw. Kejuruteraan Geoteknik, JKR
Prof. Emeritus Dato' Dr. Ibrahim Bin Komoo	Universiti Kebangsaan Malaysia (UKM)
Prof. Dr. Hj. Edy Tonnizam Bin Mohamad	Universiti Teknologi Malaysia (UTM)
Prof. Madya Dr. Rosli Bin Saad	Universiti Sains Malaysia (USM)
Dato' Ir. Prof. Dr. Dr. Gue See Sew	G & P Professionals Sdn. Bhd.
Ir. Neoh Cheng Aik	E-Geo Consultant Sdn. Bhd.
Ir. Amir Hamzah Bin Mustapha	LR Two Consult Sdn. Bhd.
Tn. Hj. Abdul Rahman bin Abdul Aziz	JKR (Retiree)

Special thanks and appreciation to proof reader Mrs. Zamzarina Binti Mohd. Sarin from Cawangan Jalan, JKR. Appreciation also to Secretariat, Research and Development Department of Cawangan Kejuruteraan Geoteknik throughout the preparation and compilation of the document.

Finally, the publisher would like to express its gratitude to the above committee members, and all those who were involved, directly or indirectly, for their tireless effort and contribution towards the successful completion of this document.

Appreciation also goes to Ir. Abdul Hadi Bin Abdul Aziz (Director of Caw. Kej. Geoteknik (Oct. 2017 – Sept. 2019)), Ir. Razali Bin Che Embi (Director of Caw. Kej. Geoteknik (Sept. 2019 – Aug. 2020)), Dato' Ir. Haji Che Noor Azeman Bin Yusoff (Director of Road & Bridge Engineering Specialist, Caw. Jalan (Jan. 2017 – July 2020) the for their full support and cooperation.

This Specification is specially dedicated to:

Ir. Ismail Bin Mohamad (Chairman)

" He passed away in the preparation of this Specification. May the effort to publish this Specification be accepted by Allah as his charity and may Allah place him among the believers and pious deeds. "

SECTION 2 – EARTHWORKS

TABLE

APPENDIX A

APPENDIX B

APPENDIX C

SECTION 2 - EARTHWORKS

2.1 GENERAL REQUIREMENT

This specification covers the construction of the earthworks including the clearing and removing of all obstacles within the limits of the earthworks; the excavation of all cuts, including excavation below the final subgrade surface; the excavation of borrow areas, benches and surface drainage facilities; the transport of the excavated material to fill or waste; and construction of the fills and subgrade; shaping, trimming, turfing and maintaining of the works, in conformity with the Drawings and in accordance to the Specifications.

The excavation and earthworks shall be executed in such a manner and order as approved by the S.O. The Contractor shall be responsible for compliance with any by-laws and regulations relating to earthworks.

Excavation in rock mass and/or hard mass shall respectively be measured and paid for as extra over to excavation of earthworks and in accordance with the Provisional Bill of Quantities (B.Q.). The Contractor shall give reasonable notice to the S.O. to examine, classify the excavation and to take measurement prior to breaking up.

For contract based on Specifications and Drawings, unless otherwise provided in the Contract for the purpose of pricing the excavation and earthworks, the whole excavation shall be assumed to be without rock mass and/or hard mass as defined hereafter.

For contract based on Quantities, the pricing shall be in accordance with the B.Q and deem to include all testing required by this specification.

Computation of volume for rock mass excavation for the purpose of payment shall be based on nett volume excavated.

The Contractor shall comply with all statutory requirements and regulations such as payment of royalties and environmental protection for removal of unsuitable material and borrow materials.

The Contractor shall provide where necessary temporary water courses, ditches, drains, pumping or other means of maintaining the earthworks free from water. Such provision shall include carrying out the work of forming the cuttings and embankments in such a manner that their surfaces at all times are at sufficient gradient to enable them to shed water and prevent water ponding.

In pumping water out from excavation and in the lowering of water table, the Contractor shall pay due regard to the stability and settlement of all structures.

Adequate means for trapping silt shall be provided on all temporary drainage systems. Similar arrangements shall be made for all earthworks including excavation whether for pile trenches, foundations or cuttings.

Should the surface of completed areas be damaged by erosion or by any other causes, the Contractor at his own cost shall make good such areas to the approval of the S.O.

The Contractor shall exercise care in preventing wastage of suitable material needed for embankment or fill construction.

2.2 METHOD OF CONSTRUCTION

The Contractor shall submit to the S.O. detailed method statement for earthworks. For the purpose of this clause, the method statement shall contain:

(a) Detailed construction sequences.
(b) Shop drawings showing details of all special requirements for the construction activities.
(c) Design calculation of key temporary works endorsed by Professional Engineer.
(d) Materials, plants, machineries and labour requirements at each construction stages.
(e) Rate of production output based on resources allocations.
(f) Other relevant information.

If requested by S.O, the Contractor shall submit additional information pertaining to the method of construction.

The contractor's method of construction shall comply with stringent of either the statutory limits imposed on lateral and vertical ground movements, construction noise, vibration and air pollution levels, or such limits necessary for the adequate protection and proper functioning of neighbouring roadways, buildings and their facilities as agreed with the S.O. The Contractor's compliance with these limits shall not relieve him of his sole responsibility for all consequential damages to adjoining structures, roads and other properties caused by excavation work.

The Contractor shall conduct condition survey prior to excavation at nearby existing structures within 500 m away of the proposed excavation works. The Contractor shall submit Environmental Management Plan (EMP) to the S.O for further confirmation and execution of the paid works.

The Contractor shall not change the methods that had been approved by the S.O. Approval by the S.O. of the Contractor's proposed methods of construction in accordance with the clause shall not in any way relieve the Contractor of any of his duties or responsibilities under the Contract.

2.3 SITE CLEARING, GRUBBING AND STRIPPING TOPSOIL

2.3.1 Description

This work shall consist of clearing, grubbing and stripping topsoil in the areas within the limits of Works designated hereunder and/or shown on the Drawings, and of clearing only in other areas designated hereunder and/or shown on the Drawings all as specified herein and as required by the S.O. The work shall also include the demolition and disposal of structures in the said areas, except where otherwise provided for in the Contract, as specified herein and as required by the S.O.

2.3.1.1 Site Clearing

The areas where the Works are to be carried out shall be cleared as described in Sub-Section 2.3.1, unless otherwise shown on the Drawings and/or directed by the S.O.

Clearing shall be carried out to the extents deemed necessary and approved or directed by the S.O. in areas outside the road reserve where channel excavation or other work is required.

In areas which are to be cleared only, and in which grubbing and stripping topsoil are not required, method of works shall be such as will not unduly damage the surface vegetation and topsoil, and care shall be taken not to disturb the topsoil and the root systems of grasses and other surface vegetation. No topsoil shall be removed from such areas, except as directed by the S.O., and any topsoil, grasses and other surface vegetation otherwise removed or disturbed shall be replaced and made good at the Contractor's own expense, with the agreement of the S.O.

Unless otherwise shown on the Drawings and/or directed by the S.O., clearing, grubbing and stripping of topsoil shall be carried out in all areas of roadway excavation and in all areas where embankment is to be constructed, except that grubbing and stripping topsoil shall not be carried out in those areas where embankment is to be constructed on ground identified as swamp or soft ground.

Clearing shall consist of cutting and/or taking down, removing and disposing of everything above ground level, including objects such as walls, fences, drains and other obstructions, except specific trees, vegetation's, structures or parts of structures and other things which are designated in the Contract to remain, or well be removed by others, or which the S.O. directs to be left undisturbed. The material to be cleared shall include but not necessarily limited to trees, stumps (parts above ground), logs, brushwood, undergrowth, long grasses, crops, loose vegetable matter and structures (except those structures whose removal or clearance is otherwise provided for in the Contract). Clearing shall also include levelling of obsolete dikes, terraces, ditches, etc., unless otherwise stated and directed by the S.O.

All holes and cavities on the ground surface after clearing, grubbing and stripping topsoil shall be filled with materials similar to the adjacent ground, and such fill shall be compacted to a dry density as specified by Sub-Section 2.4.4.4 (c), with the agreement and approval of S.O.

This work shall be considered incidental to the work of clearing, grubbing and striping topsoil, and shall not be measured for payment.

2.3.1.2 Grubbing

Grubbing shall consist of removing and disposing of surface vegetation, bases of stumps, roots, underground parts of structures, and other obstructions to a depth of at least 500 mm below ground level, with the agreement of the S.O.

2.3.1.3 Stripping topsoil

Stripping topsoil shall consist of the removing of topsoil to an average depth of at least 100 mm below ground level, and its stockpiling for use in the Works, and/or its disposal, as directed by the S.O.

2.3.1.4 Topsoil

Topsoil to be stockpiled for the Works shall be sufficiently fertile to promote and support the growth of vegetation, and shall be taken from such areas where clearing, grubbing and stripping topsoil is required as approved or directed by the S.O. Before stockpiling, topsoil shall be separated from objectionable materials as defined in Sub-Section 2.3.1.7, with the agreement of the S.O. The Contractor shall arrange for stockpile sites either within or outside the road reserve, at his own expense, and with the agreement of the S.O. or as required by the relevant laws and regulations.

Otherwise, topsoil removed during grubbing and stripping operations shall be separated from objectionable materials and spread within the road reserve or borrow areas, or otherwise disposed of, as approved or directed by the S.O.

2.3.1.5 Timber

The ownership of timber is vested in the Government.

Saleable timber shall be trimmed and stacked in accordance with the requirements of the appropriate Government agency, in accessible places within the road reserve as approved or directed by the S.O.

The Contractor shall have the right to use unsaleable timber (or saleable timber when permission is granted in writing by the appropriate Government agency or authority) for his own purposes in connection with the Contract provided that he shall comply with the requirements and approval of the S.O.

2.3.1.6 Structures

Major structures are those which cannot practicably be cleared by bulldozer and/or hydraulic excavator, whose demolition requires pneumatic tools, explosives and/or other specialised equipment. A brief description of each major structure (if any) and depth to which extent it shall be demolished is given in the Bill of Quantities (B.Q.).

All fences, buildings, structures, and encumbrances of any character within the limits of the Works, except those to be removed by others or designated to remain, shall be demolished and removed by the Contractor.

Materials designated in the Contract or directed by the S.O. to be salvaged, shall be carefully removed and stored, and shall be the property of the Government.

2.3.1.7 Disposal and Dumping

All materials resulted from site clearing shall be dumped to the Contractor's dump site as approved by the S.O. The contractor at his own expenses shall be responsible for the removing and dumping of all materials in accordance with Environmental Quality Act 1974 and Solid Waste and Public Cleansing Management Act 2007.

Objectionable material such as combustible material including all timber (except timber to be salvaged or used), all brushwood, stumps, roots, vegetation from clearing, grubbing and stripping topsoil (including the demolition of structures) shall be disposed as approved or directed by the S.O.

2.4 EARTHWORKS

2.4.1 Definitions

(a) Formation Level

Formation level means the top surface of the sub-grade.

(b) Sub-grade

Sub-grade means part of the embankment or existing ground in cutting which is immediately below the sub-base or lower sub-base of the road pavement and shoulders.

(c) Common Excavation

Common excavation means excavation in any materials which exclude hard mass or rock mass as defined in Sub-Section 2.4.1 (f) and Sub-Section 2.4.1 (g).

(d) Unsuitable Materials

Unsuitable materials shall include:

(i) Running silt, peat, logs, stumps, roots, grass and other vegetable matter, perishable or toxic material, slurry or mud; or

(ii) Organic clay and organic silt; or

(iii) Any material

- which is susceptible to spontaneous combustion; and/or
- which is clay having a liquid limit exceeding 80% and/or plasticity index exceeding 55%; and/or
- which has a loss of weight greater than 2.5% on ignition; and/or

- which has a volumetric change greater than 3% in California Bearing Ratio (CBR) test under 4 days-soaked condition (for the top 300 mm of subgrade only).

Materials that are soft or unstable merely because they are highly saturated or too dry for effective compaction are not classified as unsuitable material, unless otherwise classified or stated by the S.O.

(e) Suitable materials

Suitable materials shall mean those materials other than the unsuitable materials defined in Sub-Section 2.4.1 (d).

General fill shall generally comprise of suitable materials made up of either cohesive soil or cohesionless soil or mixture of both. The classification of cohesive and cohesionless soil shall be based on Soil Classification System set out in the MS 1056: Method of Test for Soil for Civil Engineering Purposes.

Special fill shall comprise of material, which would otherwise be classified as general fill but contains durable well-graded natural sand and gravel or crushed rock, other than argillaceous rock (e.g. mudstone, shale), or durable clean crushed demolition rubble of similar particle size and free from any contaminants.

(f) Hard mass

Hard mass could be termed as semi cemented sediments, weathered rock mass and highly fractured rock mass where the excavation work depends on the machinery and production rate as specified below:

Excavator (Series 400) with minimum weight of 41.4 tonnes and nett horsepower rating of 321 brake horsepower (BHP) with a production rate not exceeding 50 m^3 / hour.

Hard mass shall exclude individual masses less than 0.5 m^3 that shall be considered as common excavation.

(g) Rock Mass

Rock mass shall mean fresh to moderately weathered rock found in ledges or masses where the excavation work depends on the machinery, equipment and production rate as specified below:

Bulldozer ripper: Track-type tractor (D8 Dozer) with minimum weight 37 tonnes and nett horsepower rating of 303 brake horsepower (BHP) or more and attached with ripping equipment with a production rate less than 20 m^3/hour. The ripping equipment to be attached shall have a single shank in good working condition with sharpened cutting point with a minimum penetration force of 120 kN.

Boulders or detached pieces shall only be regarded as rock if they individually exceed 0.5 m^3. For boulders or detached pieces individually measuring less than 0.5 m^3, it shall be considered as common excavation.

For determination of the volume of individual boulder, diameters of the boulder in three (3) orthogonal directions shall be taken. The average of the three (3) dimensions shall be used to calculate the volume of boulder.

Records of measurements and photographs shall be taken and recorded kept supporting the calculation of the volume of boulder.

2.4.2 Confirmation of Hard Mass or Rock Mass Excavation

Confirmation of hard mass or rock mass excavation shall be verified by direct method and indirect method as described below:

(a) Direct Method by Trial Excavation

Trial excavation shall be carried out using the machineries and equipment as specified in Sub-Section 2.4.1 (f) and Sub-Section 2.4.1 (g) to confirm that the excavated material is categorized under hard mass or rock mass excavation based on its hourly production rate. The trial excavation shall be carried out on a flat platform (as much as possible) in order to develop the rated horsepower at maximum efficiency. All machineries shall be run in good condition and operated by skilled personnel approved by the S.O.

In the event where the Contractor unable to provide the machineries as stated in Sub-Sections 2.4.1 (f) and Sub-Sections 2.4.1 (g), the Contractor may propose similar machine that can be used at site for the purpose of trial excavation for the S.O. approval. The equivalent production rate of the machine can be calculated by referring to the table as shown in **APPENDIX 2A**.

The ripper unit shall be used in excavation of hard mass and rock mass only and shall not be used in common excavation.

(b) Indirect Method by Point Load Test

Point load test shall be carried out on excavated material for this purpose by using portable point load tester apparatus. Minimum ten (10) rock samples from the excavated material resulted from the direct method by trial excavation (as described in (a)) shall be tested and the results interpretation are shown in **TABLE 2.1**. Sample to be tested shall have size not less than 30mm and not more than 85mm with the preferred dimension about 50mm according to ASTM D5731 (see **APPENDIX 2B**).

TABLE 2.1: CATEGORY OF EXCAVATION BASED ON CORRECTED POINT LOAD TEST INDEX, $I_{s(50)}$

Type of Excavation	Corrected Point Load Test Index, $I_{s(50)}$
Common Excavation	Not applicable (no solid sample can be tested)
Hard Mass	< 80% of the samples obtain result < 2MPa
Rock Mass	$\geq$ 80% of the samples obtain result $\geq$ 2MPa

The provision of point load test equipment at site for the above-mentioned testing shall be at Contractor's own cost and time. The point load test apparatus shall be calibrated and a valid calibration certificate shall make available to the S.O. upon request.

Both criteria (i.e. direct method and indirect method) shall be fulfilled in order for the material to be classified as hard mass or rock mass. Confirmation test shall be carried out again when in S.O.'s opinion if the materials excavated are different from the trial excavation before.

2.4.3 Roadway Excavation

2.4.3.1 General

Wherever applicable, this Section shall be read together with JKR Standard Specification for Roadworks, Section 20: Ground Improvement. The work involves removal of unsuitable material and/or soft soil layer and replaced with suitable material as shown in the Drawings.

2.4.3.2 Dimensional Tolerances

Slopes in cutting shall be trimmed mechanically to get neat and even surfaces and shall have gradients not steeper than shown in the Drawings. Widths of excavations shall not exceed the dimensions shown in the Drawings by more than 300 mm with encumbrance free to complete the Work, unless otherwise approved by the S.O.

2.4.3.3 Separation and Stockpiling of Suitable Material

Where excavation reveals a combination of suitable and unsuitable materials, the Contractor shall, wherever the S.O. considers it practicable, 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 Contractor shall stockpile the material separately for use as subgrade as specified in Sub-Section 2.4.7.

2.4.3.4 Removal of Excavated Material from Site

Trial pit shall be carried out prior to removal of material to be excavated to confirm water table and depth of excavation.

No excavated material shall be removed from the Site except on the direction or with the approval of the S.O. Should the Contractor be permitted to remove suitable materials from the Site to suit his operational procedure, then he shall make good any consequent deficit of fill material arising there from, at his own expense.

Unless designated dump sites have been shown in the Drawings, the Contractor shall dispose of surplus suitable material at his own dump areas outside the Site as approved by the S.O. In doing so, the Contractor shall comply with statutory requirements such as payment of royalties, environmental protection, etc. Method statement

as per Sub-Section 2.3.1.7 shall be submitted to the S.O. for his approval prior to dumping.

2.4.3.5 Removal of Unsuitable Material and/or Soft Soil Layer

The depth of removal shall be as shown in the Drawings or as determined by trial pits or JKR/Mackintosh Probe test as approved by the S.O. The trial pits or probe test shall be carried out at locations as indicated in the Drawings or as instructed by the S.O.

Unsuitable material and/or soft soil layer shall be excavated to such depth and over such area as shown on the Drawings and/or as directed by the S.O. and be transported and disposed of in an approved manner. Unless approval of the S.O. to dump and spread the unsuitable material and/or soft soil within the Site is obtained, the Contractor shall be responsible for providing his own dump site for such unsuitable material and/or soft soil.

Voids created due to removal of unsuitable material shall be backfilled with suitable material compacted to a dry density as specified by Sub-Section 2.4.4.4 (c) or that specified for the respective part earthworks or as directed by the S.O.

2.4.3.6 Replacement of Excavated Material Under Standing Water

Where it is shown on the Drawings or directed by the S.O. that replacement of excavated material shall be done under standing water, voids created due to removal of excavated material shall be backfilled with hard clean crushed rock, natural gravel or sand grading within the respective limits specified in **TABLE 2.2.**

TABLE 2.2: GRADING LIMITS OF MATERIALS FOR REPLACEMENT OF EXCAVATED MATERIAL

B.S. Sieve Size	% Passing by Weight
Crushed Rock or Gravel	
63.0 mm	100
37.5 mm	85 – 100
20.0 mm	0 – 20
10.0 mm	0 – 5
Sand	
10.0 mm	100
5.0 mm	90 – 100
1.18 mm	45 – 80
300 µm	10 – 30
150 µm	2 – 10

2.4.3.7 Sides of Excavation

The Contractor shall ensure that at all times, areas of the excavation are maintained in a safe and stable condition, and shall be responsible for the adequate provision of all shoring and strutting including sheet piling required for this purpose. All temporary works shall comply with the requirements of BS 5975 - Code of practice for temporary works procedures and the permissible stress design of false work.

2.4.3.8 Widening Cuts

The S.O. may instruct the Contractor or the Contractor himself may choose to obtain material for the Works by widening cuts. In the latter case, the Contractor shall first obtain permission and approval in writing from the S.O.

Widening of cuts shall not be permitted beyond the limits of the road reserve.

Any additional costs and time incurred that resulted from widening cuts shall be borne by the Contractor.

2.4.3.9 Excavation of Rock Mass

Rock mass excavation shall be carried out by methods appropriate to site requirements as approved by the S.O.

Where the excavation is too hard to be performed by digging, dozing, scraping, ripping, splitting, breaking, jack picking or other such methods, the Contractor may apply in writing to the S.O. for permission to blast. Such permission will be granted only if the S.O. is satisfied that all reasonable measures have been tried to carry out the excavation by methods other than blasting.

Where explosives materials are used, the Contractor shall provide a complete method statement and shall comply fully with requirements of these Specifications, or any direction, order, requirement or instruction given by the Polis Diraja Malaysia (PDRM) or any other competent authority to do so under any written law. The Contractor shall comply to the safety and hazard requirements as specify in Occupational Safety and Health Act (OSHA) and any misconduct and the use of excessive explosive shall be the responsibility of the Contractor.

All material from rock mass excavations shall be used in the works whenever it is practical.

Where the rock is at satisfactory quality, the Contractor may propose to crush and screen it to produce aggregates required for concrete, road base, sub-base, or other purposes with the prior approval of the S.O. If the Contractor choose to use substitute aggregate materials, it shall be on the Contractor's own expense and the materials shall be at acceptable and good quality and approved by the S.O.

Otherwise, excavated rock shall be used in the construction of embankment and fill, to the fullest practical extent, in either of the two (2) following ways:

(a) Excavated rock shall be broken down to maximum particle size of 300 mm and used as rock fill as described in Sub-Section 2.4.5;

(b) Excavated rock shall be broken down to maximum particle size of 150 mm, blended with suitable earth fill material in a proportion not exceeding 1 rock to 1 earth, and used as common fill.

The Contractor may fully utilize excavated rock material. The excavated rock needed for earthwork construction which the Contractor choose not to use shall be replaced at the Contractor's own expense by borrowed materials of satisfactory quality from alternative locations approved by the S.O.

2.4.3.10 Storage and Handling of Explosives

The storage and handling of explosive shall be adhered to all Authorities' requirement. The prevention of any unauthorised issue or improper use of any explosive brought on the Works shall be the responsibility of the Contractor and only experienced and qualified personnel shall be employed to handle explosives for the purpose of the Works.

2.4.3.11 Blasting

Explosives shall be used in the quantities and manner recommended by the manufacturers and blasting specialist. Blasting shall be restricted to such periods as the S.O. may prescribe and to comply with all authorities' requirements. If, in the opinion of the S.O., blasting would be dangerous to persons or properties or to any finished work, or is being carried on in a reckless manner, he may prohibit it and order the rock to be excavated by other means. Such authorisation shall not in any way relieve the Contractor of his liabilities under the Conditions of Contract.

All necessary precautions shall be taken to avoid over break. As the excavation approaches its final face, blasting with pre-splitting technique shall be carried out to reduce blast damage and create reasonably even finished surface.

2.4.3.12 Safety Measures

When blasting is carried out close to properties or roads, safety rules complying to all authorities' requirements must be strictly adhered to. Where necessary or as directed by the S.O., heavy mesh blasting mats or any other controlled materials shall be used to ensure that no damage or any harm caused to persons or properties on or off Site. Special care shall be taken on highly weathered rock mass and sensitive ground. Plaster shooting will not be permitted within 400 m of any building or structure. If traffic on any road or railway has to be interrupted for blasting operations, the Contractor shall obtain approval of his schedule for such interruption from the appropriate authorities and shall prove to the S.O. that he has obtained it, prior to the interruption.

When blasting is carried out with close proximity to sensitive structures and environmental sensitive areas, thresholds and criteria of vibration, air blast, dust, fly rock and other blasting impact shall be established for monitoring purpose.

In the event where blasting is to be executed at nearby existing structures, the Contractor shall provide monitoring instrumentation before any blasting work can commence. The Contractor shall monitor any sign of vibration/ movement that might occur during the blasting work. Any damage caused by the blasting work shall be borne by Contractor.

2.4.3.13 Insecure Material

The cut slopes shall be cleared of all rock fragments which move when pried with a crow-bar. The Contractor shall excavate any insecure material to an approved depth and build up the resulting spaces with Grade 15P concrete or masonry using rock that similar to the adjoining natural rock so as to ensure a solid face.

2.4.4 Filling Works

2.4.4.1 Material

Fill materials to form formation level shall be of suitable material obtained from excavation in cuttings. Where the quantity of such materials is inadequate, the Contractor shall obtain suitable materials from the designated borrow pits or from his own source which have been approved by the S.O.

The fill material shall be free from roots, grass, other vegetarian, clay lump or material of particles size larger than 150 mm.

The following tests should be carried out for each 1,500 m^3 of material to be placed or more frequent tests as required by the S.O.:

- Atterberg limits
- Gradation analysis
- MS 1056: Method of Test for Soil for Civil Engineering Purposes

- Compaction Test (4.5 kg rammer method)

Additional test only for material for lower sub-base and top 300 mm of subgrade:

- California Bearing Ratio (CBR) Test (4 days soak with surcharge and swell measurement)

Sand shall not be used as fill materials at outer edges of the embankment.

2.4.4.2 Borrow Pits

The Contractor shall be responsible for locating actual borrow pits on site. Designated borrow pits shown on the Drawings only indicate to the Contractor for the potential areas for borrow. Whether the Contractor obtains materials from the designated or his own borrow pit, it shall be his responsibility to ascertain the suitability of the pit with respect to the quantity and quality of the materials, which shall be subjected to the approval of the S.O. The Contractor shall pay all necessary fees, taxes or royalties to the appropriate authorities and observe all relevant and related regulations.

The Contractor shall keep the borrow pits free from water ponding and the excavation are neat and tidy. The contractor shall make sure the side-wall of the borrow pits is stable, protect the slope surface by turfing and shall carry out other necessary erosion and environmental protection measures following the agreed method statement and as instructed by the S.O.

2.4.4.3 Placement of Fill Materials

All fill materials shall be deposited in layers and brought up at a uniform rate so that all of site reach the designed level at the same time. The loose depth for each layer of fill shall be determined from the trial compaction. Each layer shall extend over the full width of the fill area and shall be compacted in accordance with the requirements of Sub-Section 2.4.4.4. Each compacted layer shall be maintained at all times with sufficient even surface of longitudinal and cross slope in order to maintain the stability and to drain away the surface water.

Where embankment is to be constructed on ground with a cross slope flatter than 1 (vertical) to 10 (horizontal) but steeper than 1 (vertical) to 30 (horizontal), the foundation material, except rock, shall be scarified to a depth of 100 mm, blended with embankment fill material and compacted as described in Sub-Section 2.4.4.4.

Where embankment is to be constructed against existing embankment or on ground with a cross-slope steeper than 1 (vertical) to 10 (horizontal), the foundation shall be excavated in all materials (including hard rock) to form benches with horizontal and vertical faces from which construction of the embankment shall proceed. The benches shall be contiguous beneath the full width of the embankment, and shall be within suitable width to accommodate construction equipment such as motor-graders, trucks, rollers, etc. Scarifying of the horizontal and vertical faces of the benches shall not normally be required, and the material excavated in forming the benches may normally be used as fill in the embankment as approved by the S.O.

2.4.4.4 Compaction

(a) General

All materials used in embankments and as fill material elsewhere shall be compacted as soon as practicable after being placed and spread. Compaction shall be undertaken to the requirements of this Section by plant approved by the S.O. All compaction requirements shall be controlled by means of field density measurement.

For compaction of embankment slope, the Contractor may either extend each compacted layer beyond the design slope surface by at least 600 mm then trim back to the required slope angle, or he may employ an agreed tow type roller to compact the sloping surface.

(b) Compaction Trials

The latest MS 1056: Method of Test for Soil for Civil Engineering Purposes - Compaction Test (4.5 kg rammer method) shall be used in determining the moisture versus density relation of soil.

The Contractor shall submit to the S.O. for his approval the proposed method of compaction for each main type of material to be used in the embankment. This shall include the type of compaction plant for each type of material and the number of passes in relation to the loose depth of material to achieve desired compaction. The maximum loose thickness for fill shall generally be limited to 400 mm unless trial compaction shows compliance with larger loose thickness and with the approval from the S.O.

The Contractor shall carry out field compaction trials, supplemented by any necessary laboratory investigations, as required by the S.O. This shall be done by using the procedures proposed by the Contractor for earthworks and shall demonstrate properly to the S.O. that all the specified requirements regarding compaction can be achieved. Compaction trials with the main types of material likely to be

encountered shall be completed before the works with the corresponding materials will be allowed to commence. Each trial area shall be not smaller than 8 m x 15 m.

For earthwork compaction of less than 100 m^3, trial compaction can be waived with approval from the S.O., but field density testing as per Sub-Section 2.4.4.4 (d) still remain necessary as and when instructed by the S.O.

The work of compaction shall be carried out as specified in Sub-Section 18.5.4 of Section 18: Soil Stabilisation.

(c) Degree of Compaction

The whole of the embankment below the top 300 mm of the subgrade shall be compacted in layers until no visible track line and to not less than 90% (for cohesive material) or 95% (for cohesionless material) of the maximum dry density determined in the latest MS 1056: Method of Test for Soil for Civil Engineering Purposes - Compaction Test (4.5 kg rammer method), unless otherwise specified in the Drawings.

(d) Field Density Testing

Field density tests on each layer of compacted earth fill shall be carried out using the sand replacement method in accordance with the latest MS 1056: Method of Test for Soil for Civil Engineering Purposes or by using other means of testing of comparable similar accuracy approved by the S.O.

(e) Moisture Control

Each layer of earth fill shall be processed as necessary to bring its moisture content to a uniform level throughout the material and suitable for compaction.

The optimum moisture content as determined by the latest MS 1056: Method of Test for Soil for Civil Engineering Purposes - Compaction Test (4.5 kg rammer method) shall be used as guide in determining the proper range of moisture content preferably on the wet side, at which each soil type shall be compacted. Water shall be added in fine spray for consistent moisture absorption in the fill. Dry sand or cement or mixture of sand and cement be added to the proper range of moisture content to obtain the required density. Satisfactory method and sufficient equipment as approved by the S.O. shall be used for the furnishing and handling of water.

If the natural water content of suitable material is too high for the proper compaction to be carried out, the Contractor can either bring down the moisture content by aeration or drying or alternatively replace it with suitable materials of compactable moisture range at his own cost.

(f) Air voids

To reduce potential of collapse compression of unsaturated cohesive fill due to wetting, the moisture content range at fill placement shall be controlled to achieve a compacted fill with allowable air void content not exceeding 5%.

2.4.4.5 Control Tests

For fill/ imported material, control test shall include a series of test consist of:

(a) Soil Classification Test: Moisture Content (MC), Liquid Limit (LL), Plastic Limit (PL), Plasticity Index (PI), Sieve Analysis and Organic Content; and

(b) MS 1056: Method of Test for Soil for Civil Engineering Purposes - Compaction Test (4.5 kg rammer method).

For compacted material, control test shall consist of one field density test which allocated evenly to each compacted layer of the entire compacted fill.

The frequency of control tests shall be in accordance with **TABLE 2.3.**

TABLE 2.3: FREQUENCY OF CONTROL TEST FOR EARTH EMBANKMENT

Type of Material	Frequency of Test
Fill/ Imported material	1 series test per 1500 m^3
Compacted material	1 field density test per 500 m^2

If specific test methods are used for the factors time of speed and economic, calibration between such tests and the master test method as per latest MS 1056: Method of Test for Soil for Civil Engineering Purposes shall be carried out at the interval of every 100 tests subject to the S.O. agreement. The calibration must be material specific and shall be performed for each material type. The non-master test method with variation of more than ± 5 % shall be rejected.

2.4.5 Rock Fill Embankment

Rock used in rock fill embankments shall be of maximum particle size of 300 mm so that it can be deposited in horizontal layers, each layer not exceeding 500 mm in compacted depth and extended over the full width of the embankment except for any specified external cover to slopes or new formation level. The materials shall be spread and levelled by a crawler tractor weighing not less than 15 tonnes.

Each layer shall consist of reasonably well graded rock and all large voids with

averaging dimension of exceeding 150 mm shall be filled with broken fragments before the next layer is placed. The top surface and side slopes of embankments formed shall be thoroughly blinded with approved fine graded material to seal the surface.

There shall be a transition layer between rock fill and earth fill or the top 300 mm of subgrade of at least 300 mm compacted thickness. This shall consist of uniformly graded crushed rock between 6 mm and 150 mm as approved by the S.O.

Each layer of rock used as rock fill in embankments shall be systematically compacted by:

- at least 12 passes of a vibrating roller with a static load per 25 mm width of roll of at least 45 kg; or
- a grid roller with load per 25 mm width of roll of at least 200 kg; or
- Other machinery and/or equipment as approved by the S.O.

2.4.6 Filling on the Soft Ground

2.4.6.1 General

This Section shall be read together with JKR Standard Specification for Roadworks, Section 20: Ground Improvement.

2.4.6.2 Foundation treatment

Where soft ground under embankment is to be treated as shown on the Drawings or as directed by the S.O., the foundation soil shall be improved as specified in Section 20: Ground Improvement.

The first layer of fill materials shall be deposited over the full width of the embankment and berms in thicknesses not more than 500 mm or as approved by the S.O. to sufficiently support earthwork machineries.

If fill materials are required to be placed under standing water, hard clean crushed rock, natural gravel or sand having grading within the respective limits specified in **TABLE 2.2** shall be used to backfill the embankment not less than 300 mm, or as shown on the Drawings, above the standing water to receive compacted suitable fill thereafter.

2.4.6.3 Surcharge and Staged Construction

Where indicated in the Contract or directed by the S.O., the embankment shall be built to different heights in stages with or without surcharge and with allowance for consolidation time periods in between stages, all in accordance with the Contract. Where surcharge is specified, the Contractor shall be responsible for the provision of surcharge material and the removal and disposal of excess material on completion of consolidation or when directed by the S.O.

The work of surcharging shall be carried out as specified in Sub-Section 20.3 of Section 20: Ground Improvement.

2.4.6.4 Geotechnical Instrumentation

Geotechnical instruments shall be provided and installed by the Contractor in the positions as shown on the Drawings for measuring intended reading at specified locations or as directed by the S.O., during and after the construction period comply to requirement specified under Section 20: Ground Improvement. The details of the geotechnical instruments shall be as shown on the Drawings and the Contractor shall be responsible for supplying, installing and maintaining the functionality of the geotechnical instruments as the work proceeds.

The Contractor shall always take all necessary measures to protect the geotechnical instruments from damage and shall repair any such damage throughout the whole duration of the Works. Necessary visible barriers shall be installed around each geotechnical instrument wherever required.

The geotechnical instrumentation shall comply to Sub-Section 20.10 in Section 20: Ground Improvement.

2.4.6.5 Monitoring Records

Joint recording of geotechnical instruments reading shall be conducted as specified. The monitoring records shall be submitted to the S.O. on an approved printed form to be supplied by the Contractor. Softcopy of monitoring records shall be submitted together with the hard copy records.

For the measurement of the volume that has settled below the original level of the foundation of the embankment, the measured settlement of each settlement gauge shall be used for volume computation.

The monitoring records of the installed instrument shall comply to Sub-Section 20.10 in Section 20: Ground Improvement.

2.4.7 Subgrade

Wherever applicable, this Section shall be read together with JKR Standard Specification for Roadworks, Section 18: Soil Stabilisation.

Material for the top 300 mm of subgrade shall have a minimum California Bearing Ratio (CBR) and specified shear strength or modulus as shown on the Drawings.

Where the CBR is not specified in the Drawings, a minimum CBR of:
- 5% (T1 – T3); and
- 12% (T4 & T5)

shall be adopted when the material is compacted to 95 % of the maximum dry density determined in the MS 1056: Method of Test for Soil for Civil Engineering Purposes - Compaction Test (4.5 kg rammer method) under 4 days-soaked condition.

[Traffic category, T1 – T5 can be referred to Table 2.5, ATJ 5/85 (Pindaan

2013) Manual for the Structural Design of Flexible Pavement]

Throughout the top 300 mm of subgrade, the material shall be compacted to not less than 95 % (for cohesive material) or 100 % (for cohesionless material) of the maximum dry density determined in the MS 1056: Method of Test for Soil for Civil Engineering Purposes - Compaction Test (4.5 kg rammer method).

In cut area, the top 300 mm of the subgrade shall be scarified and re-compacted not less than 95 % (for cohesive material) or 100 % (for cohesionless material) of the maximum dry density determined in the MS 1056: Method of Test for Soil for Civil Engineering Purposes - Compaction Test (4.5 kg rammer method). If the S.O. is agreeable that the subgrade in its natural state possesses a density exceeding the requirements, then the surface of the subgrade shall be trimmed and rolled to obtain a smooth finish.

Where the material in cut area is not complying with a minimum California Bearing Ratio (CBR) as stated above, the top 300 mm of subgrade it shall be:

- stabilised as specified in Section 18: Soil Stabilisation when it suitable to stabilise and the stabilised material shall be compacted as indicated above; or
- removed and replaced with suitable material when it unsuitable to stabilise and the replacement material shall be compacted as indicated above.

The subgrade shall be finished in a neat and workmanlike manner, and the widths of embankments and cuts shall be everywhere at least those specified or shown on the Drawings on both sides of the centreline. The top surface of the subgrade shall have the required shape, super elevation, levels and grades and shall be finished everywhere up to within plus (+) 10 mm and minus (-) 30 mm of the required level.

(a) Where rock surface extends over the whole width of the formation

The rock surface shall be trimmed to free draining profile, at or below formation levels. No high spot shall protrude above the formation levels.

Any voids or cavities more than 0.5 m below the formation level shall be filled up with approved crusher run, gravels or lean concrete that have 7 days cube strength greater than 7 N/mm^2. The rock surface shall then be brought up to the formation levels with approved crushed rock or gravel, regulated and blinded.

(b) Where rock outcrop occurs over part of the formation only

The rock outcrop shall be cut down to a level not less than 300 mm below the formation level. The surface shall then be brought up to level with compacted suitable subgrade material as indicated above.

2.4.8 Protection and Maintenance for Erosion Control

2.4.8.1 Topsoil

Topsoil stockpiled for the Works in accordance with Sub-Sections 2.3.1.3 and 2.4.2 shall be spread and lightly compacted to even thickness of 50 mm as directed by the S.O. in areas to be turfed and/or hydroseeded, or used as directed by the S.O. for tree planting, landscaping and other purposes.

2.4.8.2 Turfing

Turfing shall be carried out immediately after the exposed slope surface exceeds 100 square meters or a flight of slope within a berm/bench one week after cutting/filling on all earth slopes and other areas as shown on the Drawings or where directed by the S.O. The type of turf shall be as indicated on the Drawings or other alternative type as approved by the S.O. Turf shall be delivered to Site within 36 hours after removal from the nursery and when stored, turf shall be stacked grass to grass to a maximum height of one meter. They shall be kept moist and in shade and shall be planted within 24 hours of lifting. Where turfing is required for earthworks protection, they shall be planted immediately after cutting or filling.

Turf shall be obtained in unbroken sods with substantial amount of topsoil and shall be approximately 300 mm x 300 mm in size and 50 mm thick topsoil, from approved source, and shall be placed in position as stated above.

Turf sods shall be stacked and watered if they cannot be laid immediately after cutting.

The surfaces to be turfed shall be trimmed and thoroughly wetted. The turf shall then be carefully laid to form a complete and uniform cover as shown on the Drawings. Turf laid on slopes steeper than 1 (vertical) to 1.75 (horizontal) shall be anchored down with bamboo/wooden stakes approximately 200 mm in length where required. Approved fertiliser shall be applied after placing of turf at suitable times and at rates of application approved by the S.O.

Where close turfing is specified, the turf shall be laid to well bonded pattern with no gaps between turves and lightly tamped. For the area of spot turfing, the turf shall be laid in alternating and staggered diamond pattern with maximum gap of not exceeding 100 mm.

All turf shall be regularly watered and fertilised until the vegetation and its roots is satisfactorily established. Any dead turf shall be replaced with new turf at the Contractor's own expense.

2.4.8.3 Hydroseeding

The work of hydroseeding shall be carried out accordance with Sub-Section 16.11 in Section 16: Slope Stabilisation.

2.4.8.4 Creepers

Where creepers are introduced on gunited slopes, rocks or unsuitable materials, species shall be of Malaysian origin such as creeping fig *(ficus pumila)*, butterfly pea *(centrosema pubescens)*, creeping daisy *(sphagneticola trilobata)* or to the approval of the S.O.

The Contractor shall submit to the S.O. for his consideration and approval, at least four (4) weeks in advance of the proposed work, full details of his proposed method of planting the creepers. The information submitted shall include, but not limited to a full description of the following aspects of the work:

(a) the preparation of the areas to be planted with creepers, including the amount of topsoil if appropriate to be used and its method of application;

(b) the details and results of investigations to determine which types of creepers are compatible with the soil in the areas to be planted;

(c) the types of creepers to be used, and the function, root and growth characteristics of each type;

(d) the composition of fertilizer to be used at the time of planting the creepers and its rate of application;

(e) the composition of fertilizer to be used after planting, the times of application and the rate of application;

(f) the amounts of lime or other chemicals (if any) to be applied to improve the soil before, during and/or after planting;

(g) the cultivation and after care of the areas, including rates and frequencies of watering, fertilizing and general maintenance for at least one (1) year after planting;

(h) the time after planting required for establishing permanent, dense growth of creepers, which will require minimal maintenance;

(i) guarantees the success of the creepers planting work.

All creepers shall be regularly watered until the vegetation is satisfactorily established to the requirements of these Specifications. Any dead creepers shall be replaced at the Contractor's own expense.

2.4.8.5 Temporary Slope Protection

Should the Contractor be unable to turf / hydroseed the exposed slopes within one week after cutting, temporary protection measures such as covering with tarpaulin sheet or artificial cover to control erosion shall be taken such that no infiltration and/or no serious erosion to the adjacent slope/works.

2.4.8.6 Failure to Comply to Specification

Should the Contractor fail to implement the Works as per above Sub-Sections 2.4.8.1, 2.4.8.2, 2.4.8.3, 2.4.8.4 and 2.4.8.5 the Contractor shall bear the time and cost of turfing / hydroseeding / planting creepers /temporary slope protection works carried out by others under S.O directive.

APPENDIX 2

APPENDIX 2A

TABLE 2.4: EQUIVALENT PRODUCTION RATE OF HARD MASS BASED ON TYPES OF EXCAVATORS

Excavator Series	Weight (Tonnes)	Engine Horsepower (HP)	Factor Compared with 41.4 Tonnes (Excavator Series 400)	Equivalent Production Rate for Hard Mass (m3/hr)
150	15.4	99	0.33	16.5
200	21.2	170	0.58	29.0
250	27	188	0.63	31.5
300	31	242	0.67	33.5
350	36	271	0.75	37.5
400	41.4	321	1.0	50.0

TABLE 2.5: EQUIVALENT PRODUCTION RATE OF ROCK MASS BASED ON TYPES OF TRACK-TYPE TRACTORS WITH RIPPING EQUIPMENT (BULLDOZER RIPPER)

Dozer	Flywheel Power (kW)	Operating Weight (Tonne)	Factor Compared with 37 Tonnes (Bulldozer Ripper)	Equivalent Production Rate for Rock Mass (m^3/hr)
D6, D7	200 - 240	20 - 25	0.54	11.0
D8	303	37	1.0	20.0
D9	405	48	1.3	26.0

Note: If the Contractor provides to use machinery larger than as specified above, it should be considered equivalent to the specified capacity for the purpose of approval.

APPENDIX 2B

TABLE 2.6: EXAMPLE FORM FOR POINT LOAD TEST (PLT).

Project Name :

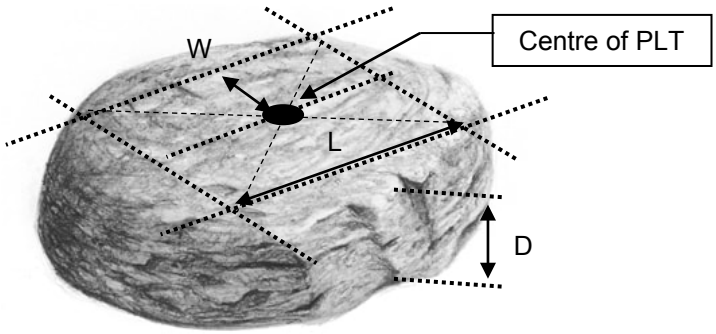
Samples from Trial Excavation No. (_____)

Location / CH : _____ (RHS / LHS / N.A)

Type of Machine : _____ Series : _____.

Minimum Weight : _____ Tonnes BHP : _____.

Sample No.	Depth, D (mm)	Length, L (mm)	Average Width, W (mm)	Load, P (kN)	D_e^2 (mm)	D_e	F	I_s (MPa)	$I_{s(50)}$ (MPa)
					$D_e^2 = 4/\pi\ (W \times D)$	$D_e = (D_e^2)^{1/2}$	$F = (D_e / 50)^{0.45}$	$I_s = P / D_e^2$	$I_{s(50)} = F \times I_s$
(1)									
(2)									
(3)									
(4)									
(5)									
(6)									
(7)									
(8)									
(9)									
(10)									
(11)									
(12)									
(13)									
(14)									
(15)									



APPENDIX 2C

FIGURE 2.1: PORTABLE HYDRAULIC POINT LOAD TESTER WITH A STAIN-GAUGED LOAD CELL AND DIGITAL READOUT FOR LOAD MONITORING (OR EQUIVALENT)

FIGURE 2.2: PORTABLE HYDRAULIC POINT LOAD TESTER WITH A PRESSURE-GAUGED READOUT FOR LOAD MONITORING (OR EQUIVALENT)

APPENDIX 2C

FIGURE 2.3: EXCAVATOR (SERIES 400) OF 41.4 TONNES AND 321 BHP (OR EQUIVALENT)

FIGURE 2.4: TRACK-TYPE OF TRACTOR (D8 DOZER) OF 37 TONNES AND 303 BHP (OR EQUIVALENT)

APPENDIX 2C

FIGURE 2.5: RIPPER UNIT / RIPPING EQUIPMENT (OR EQUIVALENT)

FIGURE 2.6: TRACK-TYPE OF TRACTOR (DOZER) ATTACHED WITH SINGLE SHANK RIPPING EQUIPMENT (BULLDOZER RIPPER) (OR EQUIVALENT)