

JABATAN KERJA RAYA

GUIDELINES FOR HARD MATERIAL/ROCK EXCAVATION

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1. INTRODUCTION

These guidelines are intended to assist the Engineer in the approval process to determine the method for excavation in rock/hard material. It also includes guidelines on the methods of measurement and necessary record keeping to enable acceptable quantification and payment to be made to the contractor.

The guidelines are not technical directives for the Engineer to decide on proper excavation methods. The technical supervising staff should be adequately competent to make engineering judgements related to site specific excavation procedures. The primary objective of the SO's approval is to choose the most optimum method for excavation in reflection to the terms of the contract and governed by site consideration.

2. CLASSIFICATION OF SOIL/HARD MATERIAL/ROCK

2.1 Preliminary Assessment

When hard material / rock removal is anticipated, the contractor must notify the SO. It is expected of the contractor to engage the services of a geotechnical engineer/geologist as well as testing agency to identify, quantify and evaluate the extent and nature of hard material /rock for removal associated with all aspects of the project.

The contractor should submit estimated quantities for the proposed work. If the estimated quantity exceeds the BQ quantity, it should be referred to the SO for further approval by the relevant authorities in accordance with their powers of approval.

The following criteria are indicative of the characteristics for the three types of material referred to in the specification. However, this should not be used for the purposes of confirming hard material or rock, even if all the criteria are met.

No	Criteria	Soil	Hard Material	Rock
1.	Geological Features	All type of general soil. Example : Clay, Peat, Loam, Sand, Residual Soil	Some fresh shale, Moderately fractured & moderately weathered rock Example : Granite, Sandstones, Schist, Slates	Fresh igneous rock, fresh metamorphic rock, fresh limestone Example : Granite, Basalt, Gabbros, Slate, Gneiss, Marble
2.	Engineering Properties • Strength Properties (kN/m ²)	Less than 1000 kN/m ²	2000 to 8000 kN/m ²	More than 8000 kN/m ²

No	Criteria	Common Excavation	Hard Material	Rock
2.	Engineering Properties (Continue) <ul style="list-style-type: none"> • Seismic Velocity (ms^{-1}) • Rock Quality Designation (RQD) 	$< 2000 \text{ ms}^{-1}$ na	$1500 - 2500 \text{ ms}^{-1}$ Less than 30 %	$> 2500 \text{ ms}^{-1}$ More than 30%
3.	Suitable Machinery & Equipment	Excavator of 44 tons and 321 BHP with minimum hydraulic pump capacity of 2x360 L / min and suitable bucket size.	Excavator more than 44 tons and 321 BHP rating Ripping using a tractor with minimum weight 37 tons and 305 BHP rating Pneumatic tools	Track type tractor with ripper exceeding weight 37 tons and 305 BHP Hydraulic rock breaker Pneumatic tools Blasting (Controlled and Open)
4.	Estimated Production Rate (per machine)	$> 1000 \text{ m}^3/\text{day}$	$400 \text{ m}^3/\text{day}$ to $1000 \text{ m}^3/\text{day}$	150 to $400 \text{ m}^3/\text{day}$ with hydraulic rock breaker.

Table 1.0 – Classification of Soil/Hard Material/Rock

2.2 Confirmation of Hard Material/Rock by Machinery

2.2.1 Trial Excavation

To determine hard material, the excavation is carried out using an excavator of 44 tons mass and 321BHP rating. If the production rate exceeds $50 \text{ m}^3/\text{hour}$, it should not be considered as hard material.

To determine rock, the trial excavation should be carried out by using a tractor unit of minimum weight of 37 tons and 305 BHP rating and a single shank ripper attachment capable of minimum penetration force of 120 kN. If the production rate exceeds $20 \text{ m}^3/\text{hour}$, it should not be considered as rock.

Trial excavation need not be repeated at new locations provided relevant soil parameters (but not limited to those in Section 2.1: Category) are proven by similar tests to match parameters obtained during the trial excavation.

If the contractor elects to use machinery larger than as specified above, it should be considered equivalent to the specified capacity for the purpose of approval.

The trial excavation shall be witnessed by the respective representatives of the Contractor and S.O.

3. METHOD OF EXCAVATION

3.1 Hard Material

Hard material excavation is that whereby the material cannot be excavated using track excavator with a mass of 44 tons and 321 BHP rating alone. In order to execute excavation in hard material, one of the following methods should be identified in the contractor's proposal:

- a. Excavator unit **exceeding** a mass of 44 tons and 321 BHP rating.
- b. A track type tractor with mounted and drawn ripper with minimum weight 37 tons and 305 BHP rating.
- c. Pneumatic tools subject to site constraint.

The contractor must maintain one the above mentioned machineries for the payment purposes of payment for hard material. If the contractor chooses to blast, it may be acceptable but this option will not be considered as rock for the proposes of payment

Whatever combination of method, the contractor should be paid for only one method of excavation as extra over common excavation.

3.2 Rock Excavation

Hard material which cannot be efficiently loosened by tractor with ripper 37 tons and 305 BHP rating falls into category of rock. It requires alternative methods. This would include the following:

- a. Pneumatic tools
- b. Hydraulic rock breaker
- c. Open blasting
- d. Controlled blasting
- e. Ripper

Rock material is to be loosened by drilling, blasting, wedging or use of pneumatic tools. The ripper is used to loosen the rock material, and loaded into trucks by excavators or by loaders and carted away.

Boulders which are larger than 0.5 m³ will be classified as rock excavation.

Whatever combination of method, the contractor should be paid for only one method of excavation as extra over common excavation.

3.2.1 Rock Excavation by Blasting

The contractor should submit a Master Blasting Plan prepared by qualified and competent staff which includes geotechnical matters and the use of

explosives. All drilling and blasting shall be performed strictly in accordance with the requirements of the SO, Government and other authorities. Proposed measures needed before commencing any blasting works are as follows:

1. Copies of current licences and permits required by Government and other authorities.
2. Details and location of work where explosives are proposed to be used.
3. Method of transportation to and from the storage magazine and the proposed method of temporary storage at the job site.
4. The size, type and location of charges.
5. The method of protection
6. The method of firing
7. The time of firing requested
8. The details of warning signals.
9. The contractor shall immediately notify the Superintendent of any misfire which occurs and shall advise the location of the misfire and the protection taken

3.3 Method Statement for Hard Material/Rock Excavation

The method statements in the contractor's proposal should include (but not limited to) all the following information:

1. The extent of the hard material/rock as exposed and shown on plan.
2. Machinery, Equipment & Tools
 - a. Type/Model
 - b. Capacity
 - c. Production Rate – soil, hard material & rock
 - d. Type/size of bucket use
3. Machinery Operators
 - a. Certification
 - b. Years of Experience
4. Construction Program/Work sequence
5. Work Procedures
6. Proposed list of test for obtaining soil/rock parameter

3.4 Machinery & Equipment

Based on Section 6.2.4 Standard Specification (Mechanical Equipment in 'Good Running Condition'), the approval for all mechanical equipment used for trial excavation shall be endorsed by JKR Mechanical Engineer before mobilization at site.

3.5 Operators

The operators shall be competent, in possession of necessary certification with minimum 3 years of experience in operating the machinery.

4. SITE MEASUREMENT & RECORD KEEPING

4.1 Method of Measurement - General

On confirmation of hard material/rock by the SO and before commencing its excavation of hard material/rock, the contractor and SO shall jointly take survey measurements sufficient to define the dimensions and elevations of the original and final surfaces of the hard material/rock.

The intervals of cross sectional survey to be carried out are recommended as follows:

- Flat terrain : 2 to 25 m
- Rolling terrain : 2 to 15 m
- Mountainous : 2 to 5 m

**The actual survey interval shall be based on site specific conditions i.e the size of the area/work to be carried out and physical constraint.*

The quantity shall be computed from the cross section measurement by the average area method. Measurements should be made by cross sectioning of the area before and after excavation on a regular basis based on work progress evaluation. The final summary report on hard material/rock excavation shall be generated and submitted to the SO as soon as the work is completed.

When boulders or rock fragment are mixed with earth, sand, gravel or other fine material and cannot be handled in the way of normal excavation, the total volume of the mixture of rock and fine material will be determined by cross sectional measurement, if practical. If not, it should be estimated by the Engineer.

Boulders or rock fragment handled separately from fine material and placed in embankment or gullies will be measured by transporting vehicles. All boulders that measure $> 0.5 \text{ m}^3$ shall be measured individually according to the specifications.

Results shall be properly recorded & submitted as a signed document by both the SO and the contractor.

4.2 Method of Measurement – Boulders and Rock Fragment

4.2.1 Measurement Based on Truck Load

All boulders and rock collected will be measured in the transporting vehicles (lorry) with consideration of bulking factor to estimate the total volume of the rock as agreed by the Engineer.

4.2.2 Measurement Based on Pile/Designated Dumping Area

Boulders or rock fragments deposited in piles/at designated dumping area will be measured by the volume of the pile.

4.2.3 Measurement Based on Material Used for Construction

When embankment in place is specified, the Engineer will determine the quantity of materials placed using cross-section and area methods. The quantity for which payment is made will not exceed that necessary to construct the embankment to the neat cross section shown in the contract documents.

4.3 Record Keeping

At least for 4 types of records need to be prepared and documented well in relation to the type of excavation carried out:

1. Trial Excavation
2. Common Excavation
3. Hard Material Excavation
4. Rock Excavation

4.3.1 Trial Excavation

- Schedule of Machinery/Equipment & Operators Details
- Schedule of Data on Classification of Soil & Test
- Schedule of Recorded Data – Production Rate, Photographs, Video, etc

4.3.2 Common Excavation

- Schedule of Machinery/Equipment & Operators Details
- Schedule of Data on Classification of Soil & Test
- Schedule of Site Measurement Data
- Schedule of Recorded Data – Photographs, Video, etc

4.3.3 Hard Material Excavation

- Schedule of Machinery/Equipment & Operators Details
- Schedule of Data on Classification of Soil & Test
- Schedule of Site Measurement Data
- Schedule of Recorded Data – Photographs, Video, etc

4.3.4 Rock Excavation

- Schedule of Machinery/Equipment & Operators Details
- Schedule of Data on Classification of Soil & Test
- Schedule of Site Measurement Data
- Schedule of Recorded Data – Photographs, Video, etc

All the above records shall also included General Information as per Section 4.8. All records shall be signed and properly bound for submission (by both the SO and the contractors).

Other than the above mentioned records, the contractor shall also submit the following:

1. Site survey log book
2. Other relevant documents...

4.4 Schedule of Recorded Data - Machinery/Equipment & Operators Details

The contractor shall provide relevant information but not limited to the following:

1. Machinery used for trial excavation
2. Type/Model
3. Capacity
4. Productivity (m³/day, trip/hours, etc)
5. Maintenance/Repair & Calibration Records
6. Condition of the machinery/equipment
7. Fuel Consumption
8. Method of excavation/Detail procedures (by contractor)
 - a. Ripping
 - b. Blast
 - c. Combination of both
9. Operators - Certification
10. Operators - Years of experience

4.5 Schedule of Recorded Data - Classification of Soil & Test

The contractor shall provide relevant information as proposed below but need not to be limited to the following:

1. Type of test performed - seismic refraction, UCS etc
2. SI reference (Drawing) & boreholes reference to the nearest location.
3. Description of the material/soil/rock - Type, visual etc
4. Test performed and benchmark value
5. Nos of test perform
6. Conclusion & Results

4.6 Schedule of Recorded Data - Site Measurement

The contractor shall provide relevant information as proposed below and not to be limited to the following:

1. Measuring equipment
2. Plan location - drawing, sketch
3. Plan drawing - estimated area/location of hard material, before & after
4. Coordinates
5. Before & after level
6. Total areas
7. Total volume of soil, hard material & rock
8. Boulder measurement/volume
9. Photo & Video

4.7 Schedule of Recorded Data – Photographs, Video etc

The contractor shall provide relevant information as proposed below as well as other information deemed to be important. The above media should be properly labelled & stored.

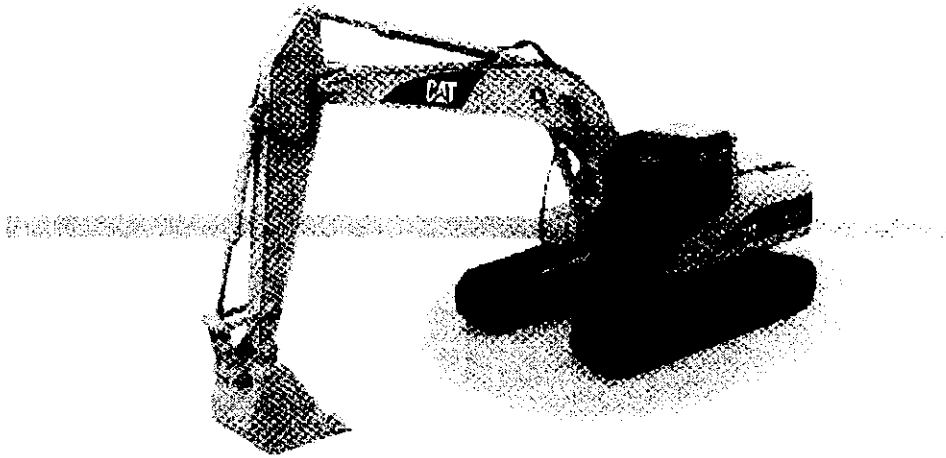
1. Location/time/duration of recorded data
2. Description of the media

4.8 General Information

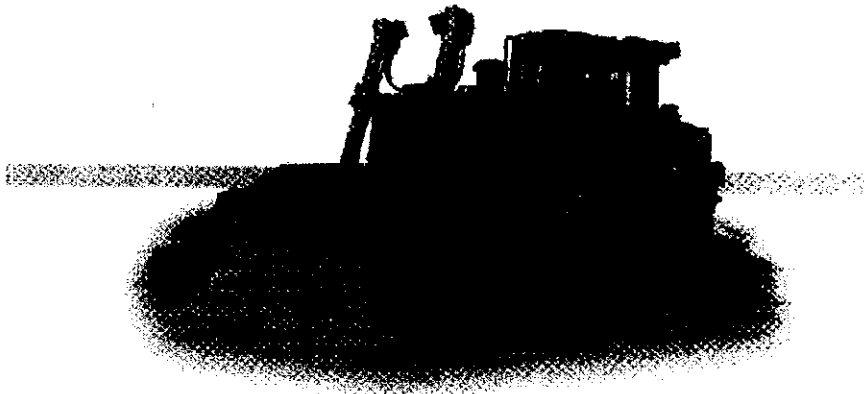
The contractor shall provide relevant information as proposed below to be accompanying with all records submitted:

1. Date
2. Time
3. Location
4. Description/Remarks – weather, site constraint, equipment failure etc.
5. Main Contractor
6. Sub Contractor (If any) – Example : IKRAM
7. Client
8. Appendix – Request for Inspection form, etc

APPENDIX 1 - MACHINERY PHOTO



**Figure 1.0 – Tack Excavator
44 Tons And 321BHP Rating**



**Figure 2.0 - Track Type Tractor/Ripper
37 Tons And 305BHP Rating**



Figure 3.0 - Track Loader



Figure 4.0 - Wheel Loader

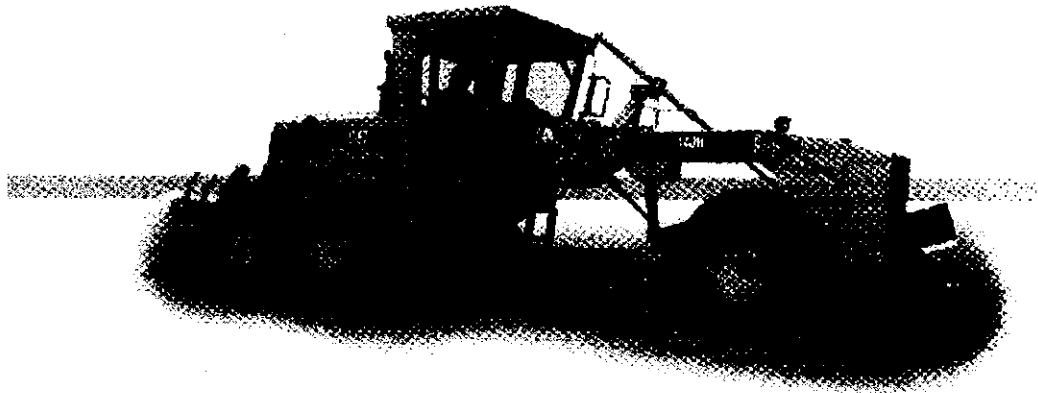


Figure 5.0 - Motor Grader

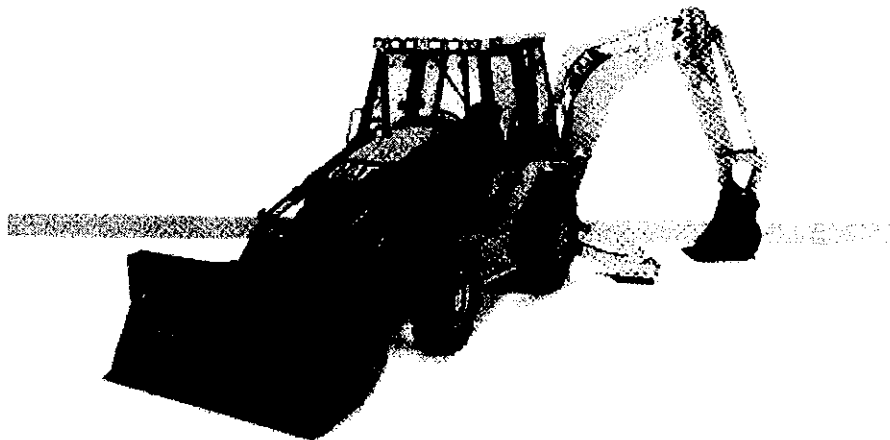
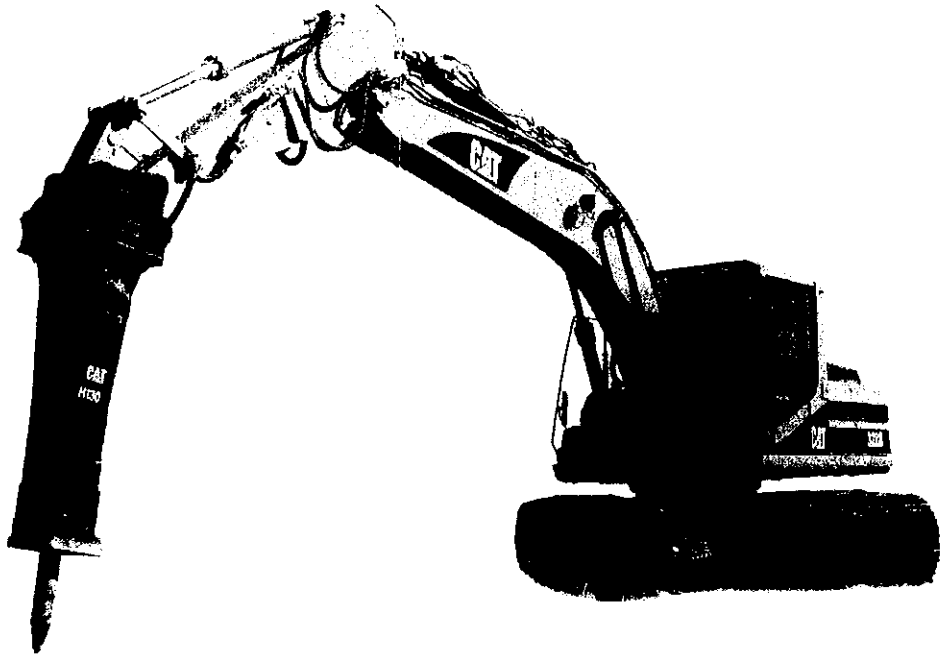


Figure 6.0 - Backhoe Loader



**Figure 7.0 – Excavator with Hydraulic
Rock Breaker**



Figure 8.0 – Hydraulic Rock Breaker

APPENDIX 2 – SPECIFICATION

1. COMMON EXCAVATION AND HARD MATERIAL/ROCK EXCAVATION

1.1 EXCAVATION

Excavation can be divided into two categories i.e. common excavation and hard material/rock excavation. Payment on excavation is to be made based on the method and equipment used

1.2 DEFINITION

1.2.1 Common Excavation

Common excavation shall mean excavation in any material other than hard material/rock excavation

1.2.2 Hard material/rock excavation

Hard material/rock excavation shall mean excavation in any material that cannot be loosened by an excavator with a minimum operating weight of 44 tons (US or short tons) and minimum engine rating of 321 BHP. The excavator shall be in "good running condition" (this term to be defined later) and operated by an experience/qualified plant operator skilled in the use of excavating equipment.

Hard material/rock excavation shall required one or a combination of the following methods:

- i. Excavation using track excavator exceeding an operating weight of 44 tons and engine rating of 321 BHP.
- ii. Ripping using a tractor unit - minimum operating weight of 37 tones and engine rating of 305 BHP - complete with ripper attachment.
- iii. Excavation involving a hydraulic rock breaker.
- iv. Excavation involving pneumatic tools.
- v. Open blasting.
- vi. Controlled blasting

Excavation of boulders smaller than 0.5m³ in volume (volume computation will be explained later) shall not be considered as hard material/rock excavation but treated as common excavation.

1.3 TRIAL EXCAVATION

Before excavation work can proceed, contractor is required to submit his method statement to the P.D. based on his proposed method of excavation. A trial excavation is then carried out to verify and confirm the practicability of the proposed method of excavation.

The trial excavation shall be witnessed by representative of the contractor and P.D. Depending on the outcome of the trial excavation, the method statement submitted can then be considered by the P.D. for approval.

In the event that the method statement is rejected by the P.D., the contractor has to submit a fresh method statement to the P.D. and the whole process of trial excavation need to be repeated to enable the P.D. to consider the new method statement for approval.

1.4 METHOD OF MEASUREMENTS

- i. Levels must be taken before and after excavation to calculate the volume for each method of excavation. Levels must be taken at 2m intervals or lesser,

- subject to approval by the P.D. The levels taken must be jointly certified by the representatives of the contractor and P.D.
- ii. Records of measurements and photographs shall be taken and kept to support the calculation of the volume of excavation.
 - iii. To determine the volume of a boulder, the "diameter" measurements in three perpendicular directions are to be taken. The average of the three measurements is used to estimate the volume of boulder concerned.

1.5 MECHANICAL EQUIPMENT IN "GOOD RUNNING CONDITION"

For the purpose of determining whether an earthmoving procedure is a common excavation or a hard material/rock excavation, it was stipulated previously that the excavator used for trial excavation and subsequent work shall be in "good running conditions".

Generally, to achieve the designed mechanical output as specified in the Original Equipment Manufacturer's (OEM) performance handbook or brochure, it is essential that the earthmoving plant concerned be kept and maintained at a high standard of mechanical efficiency, meaning that good up keeping and maintenance procedures must be strictly adhered to in compliance to OEM's recommendations.

APPENDIX 3 - BILLS OF QUANTITY FOR HARD MATERIAL/ROCK EXCAVATION

ITEM	DESCRIPTION	UNIT	QTY	RATE	AMOUNT
	<u>HARD MATERIAL/ROCK EXCAVATION (ALL PROVISIONAL)</u>				
A	<u>Extra over common excavation for excavating in rock / hard material using track excavator exceeding mass of 44 tons and 321 BHP rating as specified.</u>	M3	20000		
B	<u>Extra over common excavation for excavating in rock / hard material using a tractor unit of minimum weight of 37 tons and 305 BHP rating and a ripper attached as specified.</u>	M3	10000		
C	<u>Extra over common excavation for excavating in rock / hard material using hydraulic rock breaker as specified.</u>	M3	5000		
D	<u>Extra over common excavation for excavating in rock / hard material using pneumatic tools as specified.</u>	M3	2000		
E	<u>Extra over common excavation for excavating in rock / hard material by open blasting as specified.</u>	M3	500		
F	<u>Extra over common excavation for excavating in rock / hard material by controlled blasting as specified.</u>	M3	500		
	TOTAL CARRIED TO SUMMARY OF TENDER				