

SPECIFICATION FOR ROCK EXCAVATION

1.0 DEFINITION

'Rock' shall comprise of material found in ledges or masses in its original position or artificial material, which would normally have to be loosened either by blasting or by pneumatic tools, or if excavated by hand, by the continued use of wedges and sledge hammers and in the opinion of the Engineer is incapable of being loosened with a track-type tractor with mounted and drawn ripper of the following description:

- a) Tractor Unit: Equipment with a minimum mass of 35 tonnes and net horse power rating of 300hp or 225kW or more. The tractor unit is to be in good condition and operated by experienced personnel.
- b) Ripping Unit: The ripper to be attached to the tractor shall be the most efficient parallelogram type recommended by the tractor or ripper manufacturer. The ripper shall have a single shank in good class condition with a sharpened cutting point.

Solid rock shall be regarded as:

- a) Only solid boulders or detached pieces of rock exceeding one (1) cubic metre in volume
- b) Material not less than 20MPa of unconfined compressive strength (UCS)
- c) Production rate of less than fifty (50) cubic metres per hour for continuous of four (4) hour using 300hp excavator or ripper at full capacity.

Rock in trench or pit shall not include material which, in the judgement of the Engineer, can be excavated at a rate of four (4) cubic metres solid or more per hour by a 50hp backhoe in good order and efficiently operated.

2.0 EXPLOSIVES AND BLASTING

2.1 General

Control blasting refers to the control use of explosives and blasting accessories in carefully spaced and aligned drill holes to produce a free surface or shear plane in the rock along the specified excavation backslopes. Production blasting refers to the rock fragmentation blasts resulting from more widely spaced production holes drilled throughout the main excavation area adjacent to the control blast line. Production holes shall be detonated in a control delay sequence.

This specification only covers pre-splitting. When pre-splitting, detonate the pre-split line before the detonation of any production holes, except when the closest horizontal distance between the production line and pre-split line is greater than 20m.

For blasting of rock, the Contractor shall provide a method statement, blast design and shall comply fully with the requirements of this Clause, or any direction, order, requirement or instruction given by the Police Department or any other relevant authorities or agency under the law.

It should be noted that this Clause does not override the Contractor's obligation to satisfy the requirements of the relevant authorities but sets out the extent to which the Engineer will exercise his control in approving the Contractor's use of explosives to ensure that explosives are used always in a safe manner. It is the Contractor's sole responsibility to ensure that his method of blasting is safe, that all statutory and imposed limitations are adhered to, and to obtain a permit to use explosives from the relevant authorities and to comply with the Conditions of issue of the permit.

The Contractor shall be solely responsible for obtaining the necessary licences for the procurement, possession, transport, storage and handling of explosives and for ensuring the validity of such licences at all times. Before starting work, the Contractor shall satisfy the Engineer that all the required permits are in order and that this category of work is adequately covered in the policies of insurance.

Explosives shall be used in the quantities and manner recommended by the manufacturers.

All necessary precautions shall be taken to preserve the materials below in the soundest possible condition and also beyond the lines of all excavations.

Blasting by means of drill holes, tunnels or any other similar method shall be the responsibility of the Contractor.

The Contractor shall take all necessary precautions during blasting operations to ensure that no injury is caused to persons or damage to property or to the finished works. Shots shall be properly loaded and capped, and only appropriate charges shall be used in each hole.

2.2 Storage and Transport

Proper building or magazines, with separate compartments for detonators in suitable positions for the storage of explosives in the manner and quantities to be approved, shall be provided. Separate vehicle or vessels for detonators shall also be used for the transportations of explosives. The prevention of any unauthorised issue or improper use of any explosives brought onto the Site shall be the responsibility of the Contractor and only experienced licensed short firers shall be employed to handle the explosives for the purpose of the Works.

The relevant security regulations dealing with the storage, handling and transport of explosives shall be complied with.

2.3 Employment and Duties of Qualified Staff

The Contractor shall appoint qualified and competent licensed short firers for the planning and design of a Master Blasting Plan, geotechnical matters and use of explosives. The staff shall be appointed to specific positions to be responsible for the duties necessary to carry out excavation by the method of blasting.

Each of the above appointments will be subject to the approval of the Engineer. The staff shall be full time on site and each appointed personnel shall work exclusively on duties relating to his position.

The appointed staff shall be responsible for taking possession of explosives on site compiling of the Master Blasting Plan, preparation of the design for the blast holes drilling pattern, supervision of the drilling, establishing the explosive design, preparation of the wiring and firing sequence plan and supervision of the loading, wiring and firing of all blasts.

The appointed staff shall also undertake accurate recording of all information regarding the drilling and blasting on a "Drilling and Blasting Record Sheet" and the explosive, type, weight and delay on a "Loading Record Report". The format of the said record sheets and reports shall be to the approval of the Engineer.

The appointed staff shall attend each month or at more frequent intervals as required by the Engineer, a meeting on safety and other relevant aspects of the excavation works by blasting, which will also be attended by the Engineer's Representative.

The Contractor shall submit in writing his blasting proposals to the Engineer's Representative for approval at least 48 hours before an initial blast and at least 24 hours before any subsequent blasts.

2.3.1 Blasting Consultant

When called for in the contract, an experienced and recognized blasting consultant shall be retained to assist in the blast design. The blast design shall include both the control blasting and pre-splitting.

The blasting consultant shall possess proven experience in rock blasting design for works of similar nature. The Consultant appointed shall not be an employee of the Contractor, explosives manufacturer, or explosives distributor. Prior to the beginning of any drilling and blasting work, approval of the blasting consultant is required and the proposed rock blasting Consultant is required to submit a resume/company profile to the Engineer for this purpose.

The blasting consultant shall prepare design report or method statement which shall include, but not limited, on the proposed rock blast design, design parameters or assumptions, tolerance, precautionary measures, transport and handling, monitoring scheme, estimated productivity and time, etc for the rock blasting works.

The blasting consultant shall analyse and estimate the ground vibration levels using attenuation equation for the blasting to prevent damages to adjacent or nearby structures and services. It should be note that ground vibration depends on the maximum charge weight per delay, and not the total charge weight, provided the delay interval is significant (more than 8 ms). The blasting consultant shall also analyse and estimate the noise levels as well as design blasting to prevent flyrock and necessary precautionary measures.

It is the duty and responsibility of the blasting consultant to liaise, coordinate with Police Department or any other relevant authorities under the law during the operation of the rock blasting works inclusive of getting approval and renewal of blasting permit.

2.4 Monitoring

In order to ensure compliance with this Clause, the Contractor shall employ vibrographs suitable for measuring ground motion parameters to monitor ground vibration and air blasts at sensitive areas or at such times and locations as may be directed by the Engineer. The Contractor shall vary his blasting techniques to limit the effects upon receiving notice from the Engineer that the instruments have monitored excessive vibration at any point. The establishment of this monitoring system does not relieve the Contractor of his obligations under the Contract to monitor and record the effects of all blast vibrations, noise levels and to control the effects of his operations within the limits set out in each blasting permit.

2.4.1 Ground Vibration Measurement

Measuring Equipment

The measuring equipment should be capable of providing a direct reading of the maximum instantaneous peak particle velocity which is the vector sum of the three orthogonal ground vibration components detected by the geophone. Ground vibration should be measured with tri-axial transducers, and the measurement equipment should have a maximum absolute error of 15% over a frequency range of 5Hz (lower cut-off frequency) to 250Hz. The dynamic range of the equipment should be sufficient for the vibration levels to be measured.

The instrument should have these three components that are interconnected with cables :-

- a) Tri-axial transducer;
- b) Processor; and
- c) Recorder

The recorder should give a printed recording of the date, the time, and the resultant peak particle velocity as measured by the transducer. The tri-axial transducer housing should have indicators which show the orientation of the individual transducer components.

Measuring Technique

The transducer should be effectively and securely coupled to the ground to ensure that the transducer effectively measures the ground vibrations. The transducer should be placed on or in the ground rather than on a structure. The transducer should be located at a sufficient distance from any structure so as to avoid undue interference from the structure.

The transducer should be orientated as recommended by the manufacturer in the direction of the blast and be sunk into the ground by excavating the minimum amount of ground and tamping the transducer in the hole to provide firm contact with the ground.

When the measurement surface consists of rock, asphalt, or concrete, the transducer should be fastened to the measurement surface with either epoxy or quick-setting cement. When particle accelerations are less than 0.3g it may not be necessary to hold the transducer to the measurement surface. If particle accelerations are greater than 1.0g, bolts or cement are needed. Incorrect coupling of the transducer to the ground may lead to erroneous recordings. It is necessary when setting up the instrument, to estimate the distance from the blast and use standard tables or site charts (if available) to estimate the likely range of ground vibration in order to set appropriate scales.

2.4.2 Airblast Measurement

Measuring Equipment

The measuring equipment should be capable of measuring in decibels (dB) on a linear scale and the peak value. Airblast should be measured with equipment that has a maximum absolute error of $\pm 15\%$ (± 3 dB) over a frequency range of 2 Hz (lower cut-off frequency) to 200 Hz. The dynamic range of the equipment should be sufficient for the vibration levels to be measured. The equipment should have a recording device.

Measuring Technique

The microphone should be orientated to be most uniformly sensitive to the incident sound, and fitted with a windshield, in accordance with the manufacturer's specifications. The instrument should preferably not be held by a person, nor should it be unduly affected by reflections from nearby structures. Similarly, it should not be too close (less than 1m) to the ground.

2.4.3 Records

Blast records should incorporate ground vibration and airblast measurements. Ground vibration and airblast reports should include blast details, especially the size, location and method of initiation of the blast. Apart from specifying the instruments used, blast monitoring details may include the following :

- a) Both ground vibration and airblast responses
- b) All measurements locations (including relationship to adjacent structures and in relation to the blast site).
- c) Charges and blast method including plan of drillholes.

2.5 Flyrock Control

Before the firing of any blast in areas where flying rock may result in personal injury or unacceptable damage to property or the work, the rock shall be covered with blasting mats, soil, or other equally serviceable material, to prevent flyrock.

If using blasting mats to provide cover, the following precautions should be observed :

- a) A layer of sand or sandbags should cover the rock, at least in the area of the hole collar, to protect the mat from being damaged.
- b) Only the number of holes that can be adequately covered by blasting mats should be loaded and fired at one time. Mats should be anchored.
- c) Rock or debris should not be placed on top of the mats as these may become missiles / flying objects posing danger to personnel and properties within and adjacent to the site.
- d) If firing more than one blasthole in sequence, only short (i.e. millisecond type) delay detonators should be used. Long delays (due to half-second delay detonators or safety fuse firing) may lift the mats off the remaining unfired holes.
- e) Mats of wire rope or steel rings should not be used in the vicinity of overhead power lines.
- f) Care must be taken when laying mats so that connecting wires or detonating cord trunklines will not be damaged.

If flyrock leaves the construction site or lands on a travelled road, all blasting operations shall cease until an independent approved blasting Consultant hired by the Contractor reviews the site and determines the cause and solution to the flyrock problem. Before blasting proceeds, a written report shall be submitted to the Engineer for review and approval.

3.0 TRIAL BLASTING

Before any regular blasting commences the Contractor shall at his own expense carry out a series of trial blast tests. They are to be carried out under the supervision of the Engineer.

Trial Blast tests shall be carried out for controlled perimeter blasting technique to test the drilling accuracy necessary to achieve the required sound uniform surfaces to the completed excavations and to test the efficacy of the blasting arrangements. Unsatisfactory trial blast results include an excessive amount of fragmentation beyond the indicated lines and grade, excessive flyrock, or violation of other requirements within these specification.

The locations for such blasting trials shall be such as to demonstrate the efficacy of the proposals in respect of the prevailing rock conditions, topography, height between berms and environmental constraints. Trials for controlled perimeter blasting using the pre-splitting technique can be carried out on intermediate working faces.

The requirements for the trial blasts shall be as specified herein this Clause for the final slopes.

The resultant trial faces shall be fully exposed, all loose rock scaled and the faces evaluated by the Engineer before controlled perimeter blasting of the design slopes commences.

Further trials will be required if the Engineer considers the resultant faces to be unsatisfactory.

4.0 PRE-SPLITTING

Controlled perimeter blasting at the final rock slope surface shall be carried out using the pre-splitting technique.

In order to preserve the structural integrity of the rock faces formed, the excavation method adopted will be adjusted to suit the prevailing conditions in terms of degree of weathering, degree and orientation of natural fractures and inherent structural weaknesses and topography and burden consideration.

Before drilling the pre-splitting holes, completely remove all overburden soil and loose decomposed rock along the top of the excavation for a distance of at least 9 meters (30 feet) beyond the end of the hole drilling limits, or the end of the cut.

Pre-splitting shall involve a single row of holes drilled at the design inclination and spacing along the final excavation lines, generally loaded with charges. All the holes are to be fired simultaneously before the adjoining main excavation is blasted. If required to reduce ground vibrations or noise, the firing of the pre-split holes may be delayed, except that the hole to hole delay must be less than 25 milliseconds.

The average spacing and charges per hole shall be determined by trial pre-splitting blast tests for each rock type and Grade of Weathering encountered until the results are to the satisfaction of the Engineer. These trial pre-splitting blast tests are in addition to the series of trial blast tests, at the commencement of the Works and prior to carrying out pre-splitting in any area and shall be carried out at the Contractor's own expense. If not specified by the Engineer, the spacing of the hole shall be not more than 450 mm centre to centre.

Before commencing the trial pre-splitting and bulk blasts, the Contractor shall submit to the Engineer details of his proposals including the following data :

- a. Diameter of holes.
- b. Spacing of holes (not to exceed 450mm unless otherwise approved by the Engineer).
- c. Depth of pre-splitting holes.
- d. Diameter, spacing, burden and depth for main bulk blast holes.
- e. Distance from the pre-splitting face to the main face and to the last row of main blast hole.
- f. Inclination of holes.
- g. Type of explosive.
- h. Explosive charge per hole.
- i. Spacing of string charges including details of increased charges near the bottom of holes and uncharged length at the top.
- j. Length and type of stemming.
- k. Sequence and delay arrangement between the pre-splitting and adjoining main excavation blasts.
- l. No. of holes to be fired in the blast.

The Contractor's control perimeter blasting using pre-splitting technique shall generally be considered satisfactory and in conformity with these specifications for controlling the excavated rock surface on the following conditions :

- a. When the rock mass is cleanly split in the designed plane in such a way that subsequent blasting does not shatter or loosen adjacent rock which is not to be excavated.
- b. At least 60 per cent of the drill hole traces in the designated blasting plane are visible in the final rock surface, distributed uniformly, after scaling down of all loose rock.
- c. At least 80 per cent of the surface area in any single rectangular area of 50 sq m is within a 200mm wide zone outside the design perimeter plane. In any case,

presplitting shall not cause either bulging or overbreak of the finished surface by more than the hole spacing from the design perimeter plane.

- d. The tolerances regarding the drill hole length and alignment specified are satisfied.

Drill holes shall generally not offset by more than 50mm from the true location at the top of the hole and shall generally not diverge from the required line by more than 150mm in 10 metres. The diameter of the holes shall neither be less than 60mm nor greater than 80mm. No subgrade drilling shall be permitted.

No bulk ammonium nitrate and fuel oil (ANFO) shall be used in the pre-split holes. Only standard explosives manufactured especially for pre-splitting shall be used for pre-splitting in the pre-split holes.

When a satisfactory pre-splitting technique has been obtained and approved by the Engineer, it shall be used by the Contractor for subsequent pre-splitting work in the relevant rock type and Grade of Weathering unless the Contractor submits further proposals to the Engineer for approval.

If the blasting work has caused over-blasting or loss of berms / platform or reduction on the berm / platform width, the Contractor shall make good and repair the berm using dowel or rock bolts and reinforced concrete or any other means approved by the Engineer to the satisfaction of the Engineer at the contractor's own cost and no extension of time be given for the remedial works.

5.0 CONTROL PERIMETER BLASTING

Control perimeter blasting of permanent slope should be carried out using cartridge explosives. The pre-split rows shall be drilled and fired well in advance of the main excavation blasts to permit full propagation of the pre-split cracking plane. Production blasting within 20 metres of any pre-split face will not be permitted before pre-splitting has been carried out. The distance of each controlled perimeter blasting shall not exceed 10m unless otherwise agreed by the engineer.

The shots shall be properly loaded and tamped and where necessary, the Contractor shall use heavy mesh blasting nets. Strictly, no fly-rock is allowed to prevent damage to adjacent property and causing injury to people on and off site. Blasting shall be restricted to such periods as the Engineer may prescribe. The use of explosives by the Contractor in large blasts, as in seams, drifts, shafts, pits or large holes, is prohibited unless authorised in writing by the Engineer.

All drilling and blasting shall be done in such manner as to bring the excavation as close as possible to the required cross-section or profile and to disturb as little as possible the material to be left in place. Blasting by means of drill holes, tunnels or any other similar method shall be performed at the entire risk and responsibility of the Contractor, who shall have no claim to payment for any extra work occasioned by either over blast or under blast of the required cross-section or profile. In the case of over breakage, the Contractor shall reinstate the overbreak zone back to the original condition of the blasting rock masses as possible to the Engineer's satisfaction at his own expense, which also includes the subsequent remedial works due to alteration of design condition for other structural elements.

Prior to the commencement of blasting operations, the Contractor, in the presence of the Engineer shall conduct a survey of all structures and services within 500 metres of the site where blasting is proposed and any other structures which the Engineer considers may be affected, in order to determine the existing or pre-blast condition of these structure. Prior to commencing blasting operations, a dilapidation survey report, supported by photographs where necessary, listing any existing defects in the structures and services, is to be submitted to the Engineer.

All blasting works shall be carried out within the duration and time period as approved by local authority, police Department and technical agency under the law.

6.0 ACCESS TO ROCK SLOPES

The Contractor shall, where ordered by the Engineer, provide safe access to the rock slopes for the Engineer. Access shall consist of a rigid temporary structure complying to DOSH requirements that will allow the Engineer to safely examine all parts of the rock slopes during the trial stages and the pre-splitting works for the final rock slope.

Where the Engineer may wish to carry out additional inspection of the area of the slope from which rock or other materials have been removed, the Contractor shall re-erect the access to allow the additional inspection to take place where required by the Engineer.

The Contractor shall make due allowances in his programming for the time required to erect and maintain access to the rock slopes.

7.0 SAFETY

The Contractor shall provide an approved system of warning and preparing the general public and all site personnel of an impending blast by both audible and visual means and shall ensure that the blasting area is cleared of all personnel immediately prior to blasting. This system shall comply with all statutory requirements. The Contractor's attention is drawn to the need to devise adequate system for warning and clearing the public from specified areas during blasting operations and to prevent persons entering the blasting area.

When blasting is near to the proximity of existing public and private thoroughfares, traffic is to be stopped just prior to firing. This operation is to be carried out in close cooperation with the Police Department and in such a way as to cause minimum traffic delay.

All operations involving explosives shall be suspended on the approach of a thunderstorm and shall not be resumed until the storm has clearly passed.

Blasting screens shall be erected to conform with the permit conditions. Public roads, private roads and property adjacent to the site and services within the site area shall be protected by rock fall fences which will be subject to the Engineer's approval.

The Contractor shall take all necessary precautions to avoid damage to permanent and temporary works already completed. In all cases, delay blasting techniques will be mandatory with the quantity of explosives restricted to ensure that the Peak Particle Velocity generated does not exceed the limit set by the Authorities or the Engineer.

For general case of blasting with adjacent buildings, the maximum peak particle velocity measured at the ground surface should not exceed the limits recommended in Table below as abstracted from Table J1 of Australian Standards AS2187.2-1993 unless otherwise specified by the Engineer :

Type of Buildings or Structures	Peak Particle Velocity (mm/s)
Houses and low-rise residential buildings; commercial buildings not included below.	10
Commercial and industrial buildings or structures of reinforced concrete or steel construction	25
Notes :	
1. This table does not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations which may necessitate taking additional measurements on the structure itself, to detect any	

- magnification of ground vibrations which might occur within the structure. Particular attention should be given to the response of suspended floors.
2. In a specific instance where substantiated by careful investigation, a value of peak particle velocity other than that recommended in the Table may be used subjected to approval by the Engineer or Authorities.
 3. The peak particle velocities in the Table have been selected taking into consideration both human discomfort and structural integrity together with the effect on sensitive equipment located within buildings.

In the case of Waterworks structures, the ground movement induced (as measured at the Waterworks structure) shall not exceed the maximum amplitude of 102 microns. The sound level limit at areas where site personnel or public can access during blasting operation must not exceed 110dB.

The Contractor may not be permitted to use explosives in areas of the Site immediately adjacent to pylon positions. Particular limitations may apply in such areas depending on the Contractor's proposed methods of working and detailed method statement will therefore be required from the Contractor in each case, covering the methods of excavation and protection systems proposed, all of which shall be subject to the approval of the relevant authorities and the Engineer.

In all such cases particular attention should be paid to the requirements stated above and the effects on these structures and installations shall be closely monitored and the quantities of explosives limited accordingly.

Drilling rigs for shot holes shall be of the hydraulic type fitted with efficient silencers and with means of dust suppression.

8.0 SLURRY EXPLOSIVES

The pump truck from which any explosives are dispensed into the drilled holes shall be equipped with an accurate flow meter or similar measuring/recording device in order to accurately monitor and control the volume of explosives dispensed at each position.

Milli-second delay detonators shall, be used in all blasting locations. The use of long second delay detonators shall be limited. Sequential timers may be used only on the direction of the Blasting Engineer and to the approval of the Engineer and then only by persons suitably qualified and under the control of the contractor's Senior Engineer.

After a charge has been wired and tested, gunny sacks shall be placed over the charged holes: blasting mats shall then be placed on top of the charge and sand bags placed on the blasting mats.

Where the relevant authorities allow the use of slurry explosives, to prevent seepage of slurry into rock cracks and fissures in drilled holes, fast cross linking fluids shall be introduced into the slurry mix to speed the gelling process and to reduce its viscosity. The Contractor's proposals in this respect shall be subject to the approval of the Engineer and shall be modified as site conditions dictate. It is to be noted that a full tubular steel and wire mesh "roofover" will be required to all areas where the Contractor elects to use slurry mix explosives, unless otherwise approved by the Engineer.

9.0 SCALING AND STABILISATION

Rock on the cut face that is loose, hanging, or creates a potentially dangerous situation during or upon completion of the excavation in each lift shall be removed or stabilised. No drilling for the next lift shall be carried out until this work is completed.

Slopes throughout the span of the contract shall be scaled at such frequency as required to removed all hazardous loose rock or overhangs.

Stabilisation shall be performed at Contractors' own expense if caused by the Contractor's blasting operations.

10.0 METHOD OF WORKING

- i. The Contractor shall adopt a method of working such that at any time, control perimeter blasting operations including the drilling of perimeter holes do not advance by more than one panel ahead of bulk blasting operations and more than two panels ahead of mucking operations to remove all blasted materials to the perimeter face, unless specially approved by the Engineer, in order that adjustments to drilling, charging and detonation can be made, appropriate to the conditions being encountered.
- ii. The Engineer will only approve a variation to the above procedure subsequent to the Contractor demonstrating the success of his working procedure in relevant rock conditions through trial blasting.
- iii. Mucking out to the perimeter faces shall be carried out carefully from the perimeter line. The final face shall be exposed and scaled in a continuous operation downwards as the last stage of the mucking out cycle. Scaling shall be carried out to remove from the face all loose material and rock fragments which move when pressed with a crowbar. The required scaling works shall be carried out using a high pressure jet or other means as appropriate.
- iv. Approval to proceed with the blasting of a subsequent panel will only be given after scaling and any rock face stabilization measures, deemed by the Engineer to be required immediately to the final slope to ensure its long term stability, have been completed. Depending on the conditions encountered the Engineer may require limited excavation either in the form of blasting (including sub-benching) or mucking out to be carried out to permit the installation of rock stabilization measures as directed by the Engineer.
- v. In certain sections of the works where the prevailing geological structure is likely to control the final face profile, the Engineer may waive the requirement for controlled perimeter excavation techniques provided that the Engineer is satisfied that other excavation equipment is capable of achieving a sound profile along a discontinuity without damage beyond that plane. In such cases, unless otherwise approved by the Engineer in writing, the main blasting adjacent to a final slope shall then be modified to include a four (4) metre wide buffer zone measured perpendicular from the final slope. The drill holes within the buffer zone shall not be larger than 50mm and the spacings, burdens (which shall not exceed the hole spacing) and charge per hole in the zone shall be suitably reduced to avoid excessive blast damage to the final face. No subgrade drilling shall be allowed in the holes above the berms.

Slopes of cuttings formed in rock are to be cleaned of all rock fragments which move when pressed with a crowbar.

Constructional traffic shall not use the surface of the bottom of a cutting unless the cutting is in rock or the Contractor maintains the level of the bottom surface at least 300mm above formation level. Any damage to the subgrade arising from such use of the surface shall be made good by the Contractor at his own expense with material having the same characteristics as the material which has been damaged. From the time the Contractor begins to trim the remaining material to formation level on any given area, the movement and use of constructional plant thereon other than that used to complete this operation shall be in accordance with the requirements.

11.0 JOINT SURVEY MEASUREMENT

11.1 Prior to Rock Excavation/Blasting

- a) Trial rock excavation shall be carried out using the equipment as mentioned in item 1.0 (Definition) above operating at full capacity (criteria/determination of rock excavation and boulder excavation) with production rate not exceeding 50m³/hour for a continuous of 4 hours duration.
- b) The contractor shall submit the catalogue and specification of the machineries to be used prior to the trial excavation.
- c) All the rock excavation works at site shall be verified and approved by Client/Consultant's Site Representative(s) before the commencement of any rock excavation/blasting works in the related area.
- d) The licensed surveyor shall start capture the exposed rock survey points upon confirmation by both Client/Consultant's Site Representative. The contractor and/or C.O.W. shall liaise closely with the licensed surveyor.
- e) For any pieces of rock is less than 1m³ then the particular pieces of rock shall be considered as boulder. For determining the volume of individual boulder, the average diameter of the boulder in three orthogonal directions shall be taken and used to calculate the volume of a boulder.

11.2 Construction Control for Joint Measurement

- a) Rock levels survey works shall be carried out by licensed surveyor before and after the trial excavation, the following minimum requirements of survey works shall be followed: -
 - (i) Survey of not more than 2m intervals in grid system for exposed area of < 50m² and not more than 4m intervals in grid system for exposed area of > 50m² and inclusive of the highest and lowest exposed rock levels
 - (ii) The survey on the exposed rock shall capture the rock profile, including any depression or irregular shape.
- b) A joint survey by the contractor and Client/Consultant's Site Representative(s) shall be carried out on exposed rock before rock excavation/blasting is carried out at the designated area as to confirm the rock survey is in order.
- c) The contractor shall inform officially the Client/Consultant's Site Representative(s) at least 24 hours prior to the joint survey.
- d) The contractor shall submit the rock survey to the consultant within 3 days for review and approval.
- e) The Client/Consultant's Site Representative(s) and the contractor shall check the actual surveyed rock levels against the interpreted rock contour and highlight any discrepancy to the consultant before rock excavation/blasting is carried out. It is considered as discrepancy if level difference is more than 2m.
- f) The rock survey works shall be carried out layer by layer according to the contractor's proposed rock excavation/blasting sequence.
- g) Daily quantity of the loading of rock material and disposing offsite shall be properly recorded by the contractor and checked by the Client/Consultant's Site Representative(s) regularly.

11.3 Post Rock Excavation/Blasting

- a) For interim claim submission, the following attachments shall be submitted to the consultants and/or project Quantity Surveyor: -

- i) As-built layout plan showing the extent of the rock excavation/blasting area (Before and after excavation within the claiming period) with indication of rock's spot levels as at the cut-off period (date)
 - ii) Cross sections of every 2m or 4m as per above intervals for rock excavation/blasting area shall be carried out at the agreed cut-off period says 7 days for continuous rock excavation or end of excavation/blasting.
 - iii) A sample of volumetric calculation for the rock excavation/blasting quantity.
- b) For final claim submission, the following attachments shall be submitted to the consultants: -
- i) Endorsed as-built layout plan by licensed surveyor on the overall extent of rock excavation/blasting with indication of rock's spot levels to the finished platform levels.
 - ii) Cross sections of every 2m or 4m as per above intervals for the overall rock excavation/blasting area.
 - iii) Compilation of all the endorsed survey levels of the excavated/blasting rock layout previously submitted in the monthly/interim claims.
 - iv) Compilation of the overall calculation example of the rock excavation/blasting quantity.

