ROCK BLASTING and CONTROL OF VIBRATION: **(SPECIAL)**

Description

This project special provision governs fracturing rock for excavation and constructing stable rock cut slopes using controlled, production and trench blasting. Controlled blasting is used to form a shear plane in rock at a certain slope by limiting the effects of blasting with presplitting, cushion or trim blasting. The purpose of controlled blasting is to construct stable rock cut slopes without damaging the rock face. Production blasting is used to fracture rock in manageable sizes for excavation. Trench blasting is used to create trenches in rock for utilities and pipes and construct open ditches. This provision also addresses secondary blasting and blasting adjacent to highway structures in lieu of Article 410-11 of the *Standard Specifications*.

Control blasting to avoid damaging public and private property. Contain flyrock in the construction limits or perform blasting such that no flyrock occurs if required in the "Project Requirements" section of this provision. When blasting in the vicinity of an open travelway, have equipment standing by to remove material that interferes with traffic flow.

Perform rock blasting, develop blast plans, provide explosive materials, drill, load and stem holes, record drilling, conduct blast surveys, monitor blasts and submit drilling records, surveys and reports in accordance with the contract and accepted submittals.

Project Requirements

Statement of Concern: This Statement of Concern is expressly written to alert the Contractor (or prospective bidders) to the fact that ordinary practices customarily considered as standard for the blasting industry will not be acceptable on this project. Extra caution and skill will be required to accomplish this work in a satisfactory manner. Blasting must be safely done near residential and commercial structures; utilities; and historical structures. Because of these concerns, NCDOT will exercise their prerogative to examine carefully the qualifications of any persons whose knowledge and skills may bear on the outcome of the work. In addition, NCDOT will reject any persons who are deemed unqualified for any tasks that may be required to accomplish the blasting and monitoring work.

(A) Pre-Construction Condition Surveys

The condition of all buildings, improvements and surface utilities located within 500 feet of all locations where blasting may occur shall be surveyed at least 30 days before any holes are drilled for blasting operations. Condition survey reports and the experience of persons performing the surveys shall conform to standards provided in Section (C) (3) of these special provisions. Similar surveys, done to the same standards, shall be done at all buildings, improvements and surface utilities located within 100 feet of all locations where heavy equipment is used to construct new roadways, retaining walls, and other structures associated with the work. These reports shall be submitted 30 days before any work occurs within 100 feet of identified survey targets. No heavy construction work

shall occur until NCDOT has accepted surveys done in accordance with standards provided in Section (C) (3) of these special provisions.

(B) Vibration and Air-Overpressure Limitations

All blasting work shall be designed and executed to assure the following vibration and air-overpressure limits are not exceeded.

Vibration Limits at all frequencies of motion:

Location	Warning Level	Not-to-Exceed Level
Historic Structures[1]	0.15 in/s	0.25 in/s
Residential Structures	0.35 in/s	0.5 in/s
Commercial Buildings	0.35 in/s	0.5 in/s
Public Buildings	0.35 in/s	0.5 in/s
Heavy Commercial Structures	0.75 in/s	1.0 in/s
Buried Utilities and Surface Poles	3.0 in/s	4.0 in/s
[1]Green Park Inn near station 457+00 –L-, A.G. Jonas Cottage (Laughter Home) near station 465+00 –L-, Bollinger-Hartley House near station 542+00 –L-		

Air-Overpressure Limits:

Location	Warning Level	Not-to-Exceed Level
All Surface Structures	128 dBL	130 dBL

At the Performing Arts Center, there is a large air conditioning unit in the vicinity of station 543+00 right of –L-. Verify the unit is turned off before blasting within 200 feet.

(C) Flyrock

Design and perform rock blasting such that no flyrock occurs. If flyrock occurs, the Engineer may suspend blasting operations in accordance with Article 108-7 of the Standard Specifications and require test blasts and a revised General Blast Plan. For the purposes of this work, flyrock is defined as the movement of blasted rock or debris that lands on private property, impacts any structures, or travels outside a reasonable area required to accommodate the swelling of blasted rock and overburden. Any rock that travels more than 5 feet from the limits of blasts covered with mats is also considered flyrock.

(D) Blasting Support Personnel

Retain an independent specialist to serve as the Pre-construction Condition Survey Specialist to provide pre-construction condition surveys at all defined properties in the Project Requirements.

Retain an independent specialist to serve as Vibration Monitoring Consultant and perform vibration and air-overpressure monitoring for all heavy construction work and blasting.

Retain an independent Blasting Consultant to assist in the preparation of General Blast Plans, review and modify blast plans as needed, and for participation in site meetings and public meetings. For planning and bidding purposes, the Contractor shall assume that the Blasting Consultant will make a minimum of six two-day visits to the site. The Contractor's Blasting Consultant shall also be available to attend a kick-off meeting and other meetings as requested by the Engineer.

The Contractor shall also retain a Blasting Specialist assigned full-time to this project to assist blasters with all required blast planning, logging, and reporting documentation. The Blasting Specialist shall be located at the Contractor's on-site project office.

(E) Test Blasts

Two test blasts with rock volume not exceeding 100 cubic yards are required before individual blast plans can be submitted for larger-scale production blasting.

Definitions

Air-Overpressure or Air Blast (Noise) – The pulsating pressure changes above and below ambient air pressure generated by an explosion. Air-overpressure "linear scale" measurements include low frequency noise with a 2 hertz (Hz) response and are expressed in units of decibels-L (dBL).

Blast Pattern – A plan of blast hole locations or an expression of the burden and spacing distance and their relationship to each other.

Burden **–** The amount of rock broken by an explosive charge measured as the distance between the blast hole and the nearest free face.

Charge per Delay (W) – The sum of all charge weights firing within any 8 milliseconds (ms) time period. For example, if two 10 lb (4.5 kg) charges fire at 100 ms and one 15 lb (6.8 kg) charge fires at 105 ms, the charge per delay would be 35 lbs (15.8 kg).

Cushion or Trim Blasting – A controlled blasting technique in which a line of blast holes along a rock face is detonated during the last delay period of the blast. The main burden is moved from the face by production blast holes leaving only a small burden to be removed by the line of blast holes at the face. Charges in these holes are lighter than charges in the production blast holes.

Deck Loading (Decking) **–** A method of loading blast holes in which two or more explosive charges, called decks or deck charges, are loaded in the same hole separated by stemming or an air cushion.

Delay Blasting **–** The practice of initiating individual explosive decks, blast holes or rows of holes at predetermined time intervals using delays or delay detonators as compared to firing all blast holes simultaneously.

Flyrock – Rocks propelled through the air by the force of an explosion. For the purposes of this work, flyrock is defined as the movement of blasted rock or debris that lands on private property, impacts any structures, or travels outside a reasonable area required to accommodate the swelling of blasted rock and overburden. Any rock that travels more than 5 feet from the limits of blasts covered with mats is also considered flyrock.

Free Face **–** A rock surface exposed to air or water that provides room for expansion upon fragmentation.

Magazine **–** Any building, structure or container, approved for storage of explosive materials other than an explosive manufacturing building.

Misfire **–** An event where all or some charges in a blast fail (do not detonate) when initiated or a term for any portion of explosive materials that fail to detonate as planned.

Peak Particle Velocity (PPV) – The maximum ground vibration velocity measured in the vertical, longitudinal or transverse direction. PPV measurement units are expressed in inches or millimeters per second (in/sec or mm/sec).

Presplitting – A controlled blasting technique that results in continuous or semi-continuous fracture between blast holes.

Scaled Distance (Ds) – A calculated value in units of $ft/lb^{0.5}$ ($m/kg^{0.5}$) describing relative vibration energy based on distance to a structure (D) and charge per delay (W). Ds is equal to D divided by the square root of W, $Ds = D / W^{0.5}$ or $W = (D / Ds)^2$.

Spacing **–** The distance between blast holes in a row. In production blasting, the distance is measured parallel to the free face and perpendicular to the burden.

Stemming – Crushed stone placed in the unloaded collar area of blast holes for the purpose of confining explosive charges and limiting rock movement and air-overpressure.

Subdrilling – The portion of a blast hole that is drilled below or beyond the desired excavation depth or limit. Subdrilling is generally required to prevent the occurrence of high or tight areas of unfractured rock between blast holes.

Regulations

Comply with all the latest applicable Federal, State and local codes, laws, rules and regulations as well as professional society standards for the storage, transportation and use of explosives. These include but are not limited to the following:

- The Occupational Safety and Health (OSH) Act of 1970 and the Construction Safety Act (CSA) of 1969, as amended
- Safe Explosives Act, Title XI, Subtitle C of Public Law 107-296; Interim Final Rule

- Title 29, U. S. Code, Section 651 et seq., including safety and health regulations for construction
- Title 27, Code of Federal Regulations (27 CFR), Part 555, U. S. Department of Justice, Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF)
- Organized Crime Control Act of 1970, Title XI, Public Law 91-452, as amended
- Title 49, Code of Federal Regulations (49 CFR), Parts 105-177 (DOT RSPA) & Parts 301-399 (DOT FHA)
- Title 29, Code of Federal Regulations (29 CFR), Parts 1910 & 1926, N. C. Department of Labor, Division of Occupational Safety and Health
- The Mining Act of 1971, North Carolina General Statute, Chapter 74, Article 7, as amended
- Fire Code of North Carolina, Section 105.6.15 Explosives
- Administrative Rules, 13 NCAC 06.0521 – 13 NCAC 06.0526, N. C. Department of Labor
- "A Guide to the Safe Storage of Explosive Materials" and "North Carolina Occupational Safety and Health Standards in Construction for Blasting & Use of Explosives", N. C. Department of Labor

Keep a copy of all regulations listed above at the project site.

Non-regulatory Industry Support Organizations:

- Blast Monitoring Equipment Operation Standards (1999), Vibration Subcommittee of the International Society of Explosive Engineers (ISEE)
- Institute of Makers of Explosives (IME) Safety Library Publications (SLPs)

In case of conflict, the more stringent regulation applies.

Submittals

In lieu of a blasting plan in accordance with Article 107-11 of the *Standard Specifications*, the following submittals are required for rock blasting.

- Blasting Contractor Personnel and Experience including Blasting Consultant and Blasting Specialist
- General Blast Plan including Vibration Monitoring Consultant
- Pre-construction Condition Surveys
- Drill Logs, Individual Blast Plans and Post-blast Reports as defined in the Blasting Documentation System required for all blasting.
- Blast Damage Report, when necessary

For the Individual Blast Plans, drill logs and post-blast reports, submit two hard copies of each to the Resident Engineer. After completing all blasting for a cut, structure or an excavation, submit electronic copies in PDF format.

Allow 30 calendar days upon receipt by the Department for the review and acceptance of the Blasting Contractor and Support Personnel and Experience and General Blast Plan. Provide these submittals in both electronic and hard copy form in accordance with the following:

Submit one hard copy to the Resident Engineer. At the same time, submit a second hard copy and an electronic copy (PDF on CD or DVD) directly to the Geotechnical Engineering Unit at the following addresses:

Western Regional Geotechnical Manager
North Carolina Department of
Transportation
Geotechnical Engineering Unit
Western Regional Office
5253 Z Max Boulevard
Harrisburg, NC 28075

The Engineer may suspend blasting operations in accordance with Article 108-7 of the *Standard Specifications* if submittals are illegible, incomplete or not provided.

(A) Blasting Contractor and Support Personnel Experience

The Engineer may waive this submittal if a Blasting Consultant is not required and the Blasting Contractor and Blaster-in-Charge for this project were previously accepted within the last year for another NCDOT project with subsurface conditions and blasting of a scope and complexity similar to that anticipated for this project.

Obtain acceptance of the Blasting Contractor personnel and experience before submitting a General Blast Plan.

(1) Blasting Contractor

Use a Blasting Contractor prequalified by the NCDOT Contractual Services Unit for rock blasting work (work code 070). Submit documentation that the Blasting Contractor has successfully completed at least 5 blasting projects within the last 3 years with subsurface conditions and blasting of a scope and complexity similar to that anticipated for this project. Documentation should include the General Contractor and Owner's name, descriptions of each past project, and current contact information of a representative of the project owner or construction manager. Contact information shall include at lease one valid phone number.

(2) Blaster-in-Charge

The Blaster-in-Charge has total authority over the handling, use and security of explosives and is responsible for coordinating, planning and supervising explosives use. The Blaster-in-Charge is also responsible for inspecting blast

areas and completing check-list activities identified in the blast planning form included in the Blasting Documentation System. Either the Blaster-in-Charge or an alternate Blaster-in-Charge is required to be on-site during blasting. All acting Blasters-in-Charge must be preapproved by NCDOT.

Provide verification of employment with the Blasting Contractor for the Blaster-in-Charge and any alternate Blasters-in-Charge assigned to this project. Submit documentation that each Blaster-in-Charge has a minimum of 5 years experience in blasting with past projects of scope and complexity similar to that anticipated for this project. Documentation should include resumes, references, certifications, project lists, experience descriptions and details, etc. References shall include valid phone numbers for representative of the project owner or construction manager from at least three past projects involving similar close-in blasting. The submittal shall also include a signed statement from the proposed blaster certifying that during the prior five years they: 1) not been involved in flyrock incidents, 2) have not had a blasting license restricted or revoked in any State, and 3) they have not been fined or sanctioned in any way by a regulating authority. If there is a change in the Blaster-in-Charge, discontinue explosives use until qualifications of a new Blaster-in-Charge are submitted and accepted.

(3) Blasting Consultant

When a Blasting Consultant is required in the "Project Requirements" section of this provision, submit an independent consultant. Employees of the Contractor, any affiliated companies or product suppliers are not allowed to be independent consultants. Use a Blasting Consultant prequalified by the NCDOT Contractual Services Unit for the rock blasting evaluation & design discipline.

(4) Blasting Specialist

The Contractor shall retain a Blasting Specialist with at least 5 years of direct blasting experience who can assist the blasters with all blasting documentation and submittals including drill logs, blast plans, blast reports, and vibration monitoring records. The blasting specialist must have proven computer skill to use Microsoft WORD®, EXCEL®, vibration reporting software, and other software as needed to prepare all documents and to submit them in PDF format for review by others as required.

(5) Pre-construction Condition Survey Specialist

The Contractor shall retain a third-party specialist with at least 5 years of experience in surveying structures at a minimum of five projects with similar complexity to the proposed work.

(B) Blast Plans

Blast plans are required to be signed by the Blaster-in-Charge (and Blasting Consultant, if applicable). Review and acceptance of blast plans does not relieve the Contractor of responsibility for the blast results or liability in accordance with Articles 107-11 and 107-12 of the *Standard Specifications*.

(1) General Blast Plan

Submit a General Blast Plan before beginning drilling, when revised drilling or blasting methods are proposed or as directed by the Engineer. At a minimum, include the following in the plan:

- Work procedures and safety precautions for the storage, transportation, handling and detonation of explosives
- Explosive products and devices for dry and wet blast holes including explosives, primers and detonators with material safety data sheets
- Drilling equipment and methods for maintaining blast hole alignment
- Typical plan, profile and sectional views for both production and controlled blasting showing hole diameter, depth, inclination and spacing, maximum blast limits, burden, subdrill depth and method of determining maximum charge per delay
- Initiation and delay methods and delay times
- Sample blast monitoring report format and equipment including calibration information
- Blast Monitoring Consultant, if applicable
- Test blast locations when required

Do not deliver explosives to the project site until the General Blast Plan is reviewed and accepted.

(2) Individual Blast Plan

After the General Blast Plan is accepted, submit individual blast plans at least 24 hours in advance of each blast. In addition to information shown on the Blast Planning Forms, the following is required for each individual blast plan:

- Check list activities shall be dated and initialed by the blaster-in-charge and an accepted Contractor management person to assure they have been done.
- A plan sketch of the blast area showing hole locations, free faces and any observed joints, bedding planes, weathered zones, voids or other significant rock structure that may influence the blast. Also include hole-numbers corresponding to numbers used in drill logs and note burden and spacing dimensions.
- Typical diagrams showing charge configurations including the location and amount of each type of explosives, primers, detonators, top-stemming, column heights, inert stemming decks and subdrill.

- Calculations showing maximum charge per delay determinations based on scaled distance calculations to various structures
- A delay and initiation diagram showing surface delay connections, in-hole delay times, and actual firing times of all charges.
- Predicted maximum vibration level at the most restrictive point of concern
- Description of methods that will be used to cover blasts
- Description of plans to notify residents of buildings located within 200 feet of blasts.
- Description of methods and trained personnel that will be deployed to block roadways during blasting

Drill Logs and Post Blast Reports shall be submitted within 24 hours after the time of blasting. Drill logs shall include all information shown on the forms and hole numbers shall consistent with numbers used in blast plan diagrams. Post Blast Reports shall contain all blast design information required in the blast plans and shall show as-built changes and a summary of vibration monitoring results.

(C) Blasting Documentation System for Individual Blasts

Blast planning forms, drill log forms, and post blast report forms included in the Blasting Documentation System, shall be used to document individual blasts. The Contractor may customize these forms to add more information for their own purposes. If the Contractor chooses to use their own forms, all of the information contained on forms in the Blasting Documentation System shall be included on the Contractor's forms. The Blasting Documentation System is available at the following web address:

www.ncdot.org/doh/preconstruct/ps/contracts/letting.html

(D) Pre-construction Condition Surveys

Conduct pre-construction condition surveys in accordance with the "Project Requirements" section of this provision and the accepted General Blast Plan. Text of reports shall be typed (or printed) and two copies shall be submitted.

At a minimum, reports shall include the following:

- Summary naming the person who performed the survey and comments about each structure and existing condition
- Sketches of interior and exterior walls and foundations with existing cracks and a written description of the cracks including the length, width, type and angle
- Reports shall include hard copy color photographs from 35-mm Kodak or Fuji Film, sized at least 4 x 6 inches, printed on Kodak of Fuji Film Paper in glossy format; or printed two-to-a-page on glossy photo-quality paper by a digital printer. Photos must be taken of all cracks and other damaged, weathered or otherwise deteriorated structural conditions. If necessary, macro lenses and flash illumination shall be used to ensure defects are shown clearly in the photographs. Photos shall contain an accurate date stamp.

- A walk-through video-tape with audio commentary shall be done for each surveyed structure or improvement within the specified survey boundaries. Audio comments shall include name(s) of survey staff, property type, name of owner, date and time of survey, and comments about the condition of the observed structure. Video-audio tapes shall be made with digital quality camcorders and two copies shall be submitted in DVD format Disks attached to two submitted copies of written reports.

Blast Monitoring

At a minimum, monitor vibration and air-overpressure (noise) at a minimum of three locations. One instrument shall be located at the nearest occupied building. Two other instruments shall be located at other structures or utilities of concern. All instruments and their use shall fully conform to standards published by the Vibration Section of the International Society of Explosive Engineers (ISEE). All monitoring equipment shall be calibrated within one year of the date the data is collected. Interpret the recorded data and submit a blast monitoring report signed by the Blaster-in-Charge (or Blast Monitoring Consultant, if applicable) with the post-blast report within 3 days after each blast or before the next blast, whichever is sooner.

Damage Notification

If damage occurs from blasting or if damage is alleged, notify the Engineer immediately. Submit a blast damage report signed by the Blaster-in-Charge (and Blast Monitoring Consultant, if applicable) with the post-blast report that includes the following:

- Property owner's (and injured person's, if any) names, addresses and telephone numbers
- Details and description of damage or alleged damage (and injury, if any) with photos or video
- Any associated tort claims, complaint letters and other applicable information

Blast Design Requirements

(A) Vibration and Air-overpressure Control

Design blasts for the vibration and air-overpressure (noise) warning levels and not-to-exceed limits in the "Project Requirements" section of this provision. If warning levels are exceeded, the Engineer may require additional monitoring and the Contractor should be aware that future blasts could exceed the not-to-exceed limits. If not-to-exceed limits are exceeded, the Engineer may suspend blasting operations in accordance with Article 108-7 of the *Standard Specifications* and require test blasts and a revised General Blast Plan.

Design and perform rock blasting to assure no excessive movement of rock or adjacent material occurs. If excessive movement of blasted rock or adjacent material occurs, the

Engineer will suspend blasting operations in accordance with Article 108-7 of the Standard Specifications and require test blasts and a revised General Blast Plan.

(1) Peak Particle Velocity and Scaled Distance

Use the following formulas to predict peak particle velocity (PPV) and scaled distance (Ds).

$PPV = K(Ds)^m$ and $Ds = D / (W_{max})^{0.5}$

where: PPV = Peak Particle Velocity (in/sec)
K and m = Site specific constants defining initial energy and decay
Ds = Scaled Distance ($ft/lb^{0.5}$)
D = Distance to subject structure (ft)
W_{max} = Maximum charge per delay (lbs)

For the Highway 321 Widening Project in Blowing Rock, NC, a K-value of 70 and an m-value of -1.2 shall be used until regression curves, based on at least 30 data points covering scaled distances from 20 to over 100, are developed from actual site data. The K-value based on site data must be based on the 95% upper limit curve.

(B) Test and Production Blasts

Design production blasts in accordance with the following unless otherwise approved:

- Diameter of production blast holes may not exceed 3" (76 mm).
- Only fixed-cartridge explosives shall be used for this work and the diameter of explosives shall not exceed 2.0 inches (51 mm). No ANFO or flowable (pumped) bulk explosives shall be used.
- No dynamite or nitroglycerin-based explosives should be used.
- Subdrilling of blastholes beyond the desired lines of cut slopes shall not exceed 6 inches (15 cm).
- Only shock-tube or electronic initiation systems shall be used for this work. The use of electric detonators and cap-and-fuse is prohibited. Use delay blasting to detonate production blast holes towards a free face.
- Maximum burden of rock between all portions of charges and nearest rock surface shall be at least 25-charge-diameters. For example, for 2-inch-diameter charges, minimum confining burden is 50 inches (25 x 2) or 4.2 feet.
- All charges shall be stemmed with at least 25 charge-diameters of clean washed crushed stone sized from 3/8 to ½ inch.
- All blasts located within 500 feet of structures or power lines should be covered with blasting mats or 3 feet of dirt.
- Blast benches should be wetted with sprayed water to suppress dust on days when maximum forecasted wind speed is greater than 20 mph.
- The minimum scaled distance used to limit charge-per-delay shall be 80 for occupied residential and commercial structures; and 140 for historic structures.

(C) Controlled Blasts

Controlled blasts are required for final cut slopes steeper than 2:1 (H:V) when the height of the rock face exceeds 15 ft (4.6 m).

(1) Presplitting

Presplitting is required for final cut slopes ¾:1 (H:V) or steeper. Design presplitting such that irregularities in the presplit rock face between holes does not exceed 1 ft (0.3 m) and in accordance with the following unless otherwise approved:

- Use presplit blast holes with a diameter of 2 to 3 inches (50 to 75 mm)
- Space presplit blast holes 10 times the hole diameter
- Minimize subdrilling between lifts to only the width of the horizontal offset between lifts
- Do not subdrill below final grade
- Extend presplit blast holes a minimum of 30 ft (9.1 m) beyond the limits of the production blasting or to the end of the cut section
- Bench height or lift thickness may not exceed 25 ft (7.6 m)
- Do not use ANFO or any other bulk loaded products
- Use cartridge explosives or other types of explosives specifically designed for presplitting
- The maximum charge diameter may not exceed one half the diameter of the presplit blast holes except for the charge in the bottom 2 ft (0.6 m) of the holes
- Presplitting may be performed with production blasting provided all presplit blast holes are fired at least 25 ms before the production blast holes

(2) Cushion Blasts

Cushion blasts refer to either trim or cushion blasting. Design cushion blasts in accordance with the following unless otherwise approved:

- Diameter of cushion blast holes may not exceed 6” (150 mm)
- Minimize subdrilling to only that required for excavation of the final cut slopes
- Do not subdrill below final grade
- Bench height or lift thickness may not exceed 25 ft (7.6 m)
- Use a maximum of half the charge density and burden of the production blast holes for the cushion blast holes
- Do not use bulk ANFO or any other bulk loaded products
- Fire cushion blast holes after production blast holes with a minimum 25 ms delay

(D) Trench Blasts

Design trench blasts in accordance with the following unless otherwise approved:

- Diameter of trench blast holes may not exceed 3” (75 mm)
- Do not use bulk ANFO or any other bulk loaded products

- Use cartridge explosives or other types of explosives specifically designed for trench blasting
- Use a charge diameter ½ to ¾ inch (13 to 19 mm) less than the diameter of the trench blast holes

Test Blasts

A test blast is defined as drilling, blasting and excavation of a test section before beginning or restarting full scale blasting. When test blasts are required in the "Project Requirements" section of this provision or as directed by the Engineer, perform the required number of test blasts for both production and controlled blasting (presplitting, cushion or trim blasting) or trench blasting before beginning full scale blasting. Submit proposed test blast locations with the General Blast Plan. Also, if the Engineer suspends blasting operations after full scale blasting has begun, one or more test blasts may be required before resuming blasting. When this occurs, inform the Engineer of the test blast locations before submitting any Individual Blast Plans.

Perform test blasts in accordance with the submittal, blast design and construction requirements except submit an Individual Blast Plan for test blasts 72 hours before beginning drilling. Full scale blasting may not begin or resume until the test blasts are acceptable to the Engineer. The Engineer will not consider whether a test blast is acceptable until the rock face is exposed and the post-blast report is submitted. Examples of results that may be unacceptable include excessive vibration, air-overpressure or flyrock, overbreakage, damage to the final cut slope face and overhangs.

Blasting Methods and Activities

Before beginning drilling, conduct a pre-blast kick-off meeting to discuss the blasting and monitoring. Schedule this meeting after the General Blast Plan has been submitted and accepted. The Resident Engineer, Roadway Construction Engineer, Geotechnical Operations Engineer, Contractor and Blaster-in-Charge, Blasting Consultant, and Blast Monitoring Consultantwill attend this pre-blast meeting.

Drill and blast in accordance with Individual Blast Plans, the general blast plan, and this provision as directed by the Engineer. Use explosives in accordance with all applicable government regulations, professional society standards and manufacturer guidelines and recommendations.

Remove all overburden material along the top of the excavation for a minimum of 30 ft (9.1 m) beyond the blast holes or the end of the cut unless otherwise approved. Inspect all rock surfaces to identify free faces and weaknesses for the purpose of appropriately locating blast holes so charges are adequately confined.

Drill blast holes within 3" (75 mm) of planned location and control drilling to maintain the final cut slope angles and to assure sub-drilling does not exceed specified amounts in shallow rock slopes. Accurately determine the angle at which the drill steel enters the rock. Alignment is crucial for presplit holes (if used). Drilling will not be permitted if the alignment of presplit

holes can not be verified during drilling to the satisfaction of the Engineer. Deviations in presplit holes from the required alignment by more than 6" (150 mm) either parallel or normal to the cut slope are not allowed.

Cover or plug all blast holes after drilling to prevent unwanted backfill and identify and mark each hole with hole number and depth. Blast holes are required to be free of obstructions the entire depth. Load holes without dislodging material or caving in the blasthole wall. Use standard size nos. 67 and 78M in accordance with Section 1005 of the *Standard Specifications* for stemming. Stem blast holes with diameters of 5" (250 mm) or greater with no. 67 coarse aggregate and blast holes with diameters less than 5" (250 mm) with no. 78M coarse aggregate. Do not stem blast holes with drill cuttings.

Notify all occupants of residences, businesses and structures in the surrounding area and the Engineer at least 24 hours before blasting. Check for misfires immediately after each blast before signaling all clear. Remove any loose, hanging or potentially dangerous conditions by hand or machine scaling methods. Resume drilling only after scaling is complete.

When the height of a cut requires multiple lifts or benches, offset the controlled blast holes for each subsequent lift the minimum distance necessary to allow for drill equipment clearances. Adjust the alignment of controlled blast holes to account for this offset as well as any drift that occurred in the preceding lift.

The Engineer may suspend blasting operations in accordance with Article 108-7 of the *Standard Specifications* when vibration, air-overpressure or flyrock limits are exceeded, unsatisfactory rock cut slopes are produced or other reasons.

Remove all loose material from final rock faces by scaling. The Contractor is responsible for the final rock face. If blasting damages the final rock face, stabilize the slope at no additional cost to the Department with a method proposed by the Contractor and accepted by the Department.

Secondary Blasting

Secondary blasting is used to reduce the size of naturally occurring boulders or those resulting from initial blasting. Secondary blasting methods include block holing or boulder busting. Block holing or boulder busting is the breaking of boulders by loading and firing small explosive charges in small diameter blast holes. Submit a combined general and site specific blast plan for secondary blasting.

Mud capping, which is defined as placing an unconfined explosive charge in contact with a rock surface without the use of a blast hole and covering it with mud, is not allowed.

All blast covering requirements and monitoring requirements specified for test and production blasts shall be applied for secondary blasting.

Blasting Adjacent to Highway Structures

Do not blast adjacent to highway structures until the concrete strength reaches 2400 psi (16.5 MPa). When blasting adjacent to highway structures, limit PPV to 4 in/sec (100 mm/sec) measured at a location on the structure nearest the blast. Perform blasting adjacent to highway structures in accordance with the submittal, blast design and construction requirements in this provision.

When blasting for foundation excavation, submit a combined general and site specific blast plan.

Measurement and Payment

Pre-splitting of Rock will be measured and paid for in square yards (meters). Presplitting will be measured along the presplit rock face from the toe of the slope to the crest of the presplit line. No payment will be made for unsatisfactory presplitting as determined by the Engineer.

No direct payment for rock blasting or scaling will be made. The contract unit price for *Unclassified Excavation* in accordance with Article 225-7 of the *Standard Specifications* or the lump sum price for *Grading* in accordance with Article 226-3 of the *Standard Specifications* will be full compensation for all necessary rock blasting and scaling in accordance with the contract.

No direct payment for rock blasting will be made for any pipe, utility or foundation excavation. Rock blasting for these items will be considered incidental to the compensation for the required excavation at the various locations. Where no direct payment for excavation is made, the cost for all rock blasting will be considered incidental to the required work and no separate payment for blasting will be made.

No additional payment will be made or extension of contract time allowed when the Engineer suspends blasting operations and requires test blasts, additional monitoring or submittals in accordance with this provision.

Payment will be made under:

Pay Item	**Pay Unit**
Pre-splitting of Rock	Square Yard (Meter)