S U P P L E M E N T A L S P E C I F I C A T I O N

AMENDMENT TO SECTION 203 – EXCAVATION AND EMBANKMENT

The purpose of this Supplemental Specification is to reorganize Sections 3.2 and 3.3 of the Construction Requirements, incorporating best management practices for blasting, and to revise the requirements of the General Blasting Plan, including the adoption of USBM RI8507 alternative blasting level criteria.

Replace 3.2 and 3.3 with the following:

3.2 Rock Excavation. When rock excavation is to be performed, the overburden shall be removed, or trenches shall be excavated through the overburden at the intervals directed, normally 25 ft (10 m), but in no case closer than 10 ft (5 m) apart to permit cross-sectioning of the rock in its original position. The use of power equipment will be satisfactory. Rock removed prior to sectioning will be considered as common excavation.

3.2.1 Blasting operations. The required slopes or configurations shown on the plans or ordered shall be constructed in a safe and stable condition while ensuring the safety and convenience of the public.

3.2.1.1 The Engineer will, at all times, have the authority to prohibit or halt the Contractor's blasting operations if it is apparent that through the methods being employed, the required slopes are not being obtained in a stable condition or the safety and convenience of the public is being jeopardized.

3.2.1.2 The Contractor shall schedule blasting operations so that all rock excavation within 300 ft (90 m) of any portion of a proposed bridge or within 100 ft (30 m) of any other proposed structure is completed before any structure work is started.

3.2.1.3 All blasting operations, including the storage and handling of explosives and blasting agents, shall be performed in accordance with the applicable provisions of the Standard Specifications and all other pertinent Federal, State, and local regulations. Whenever explosives are used, they shall be of such character and in such amount as are permitted by the State and local laws and ordinances, and all respective agencies having jurisdiction over them.

3.2.1.4 Pre-blast meeting. A pre-blast meeting shall be held prior to the start of any drilling or blasting activities. The purpose of the meeting shall be to review the blasting procedures and vibration monitoring requirements and to facilitate coordination between all parties involved. Individuals attending the pre-blast meeting should include the Contract Administrator, the Contractor, the Contractor's seismologist or blasting consultant, the Contractor's blaster, the Research Geologist, any utility affected by the blasting operation, and any other personnel the Engineer deems appropriate.

3.2.1.5 The Contractor shall observe the entire blast area to guard against potential hazards before commencing work in the cut. The Contractor shall not be allowed to store explosives on the project site or on State owned property unless prior approval is granted by the Department.

3.2.1.6 Blast scheduling. The Contractor shall notify the Engineer of blast round schedules in accordance with the following requirements:

(a) At least 24 hours in advance, notification of estimated time of blast.
(b) At 1 hour prior to a blast, stand-by notification.

3.2.1.7 All loose and unstable material, all breakage, and all potentially unstable rock slides, even if located beyond the payment lines, shall be removed or stabilized to the Engineer's satisfaction during or upon completion of the excavation in each lift. Drilling the next lift will not be allowed until this work has been

completed. It shall be the responsibility of the Contractor to perform all phases of this work to produce the required slopes.

3.2.1.8 Prior to the start of blasting activities, the Contractor shall place an advertisement in the local newspaper and provide a notice to adjacent property owners or tenants identifying the project, blasting Contractor, site location, warning signals, and precautions being taken by the blasting Contractor to minimize disturbance to residents.

3.2.2 General Blasting Plan. The Contractor shall submit the General Blasting Plan for review and approval to the Research Geologist at the Bureau of Materials and Research. The General Blasting Plan shall be submitted at least two weeks prior to commencing drilling and blasting operations. No drilling or blasting shall take place until the general Blasting Plan is approved by the Research Geologist. The General Blasting Plan shall include the following information:

(a) A diagrammatic description of the "Typical Blasting Pattern" to be used for the required rock excavation, including the presplitting pattern if presplitting is required. (See 3.2.9) This description shall include the spacing and depth dimensions both for the holes drilled along the presplit lines (presplit holes) and for fragmentation charge holes (production holes). The relative position of the "free face" and the burden shall also be shown, along with the anticipated cap delays to be used at each hole in the pattern. An example of such a diagrammatic plan is shown in Figure 1.

(b) A diagrammatic description of the loading plan for a "Typical Production Hole" and, if presplitting is required on the project, for a "Typical Presplit Hole". This description shall include for each type of hole the fuse and cap locations, the percent strength and type of primer, the proposed hole diameter, the percent strength and type of explosives, with brand name and density of explosive, and the anticipated location and depth of stemming. An example of such a diagrammatic plan is shown in Figure 2.

(c) Subdrilling depth; amount of explosives, primers, and initiators in each hole; initiation sequence of blastholes including delay times and delay system; and manufacturer's data sheets for all explosives, primers, and initiators to be used.

(d) Sequence and schedule of production blast rounds, including the general method of developing the excavation, lift heights, starting locations, estimated starting dates, estimated rates of progress, etc.

(e) Written evidence of the licensing, experience, and qualifications of the blaster who shall be directly responsible for the handling, use and security of explosives along with the coordinating, planning and supervising the explosive use and loading and firing of each shot, herein referred to as the blaster-in-charge. The blaster-in-charge or alternate blaster-in-charge is required to be on-site during all blasting. All acting blasters-in-charge must be pre-approved by the Department.

(f) Name and qualification of the person responsible for designing and directing the Contractor's blasting operation.

(g) Name and qualifications of the independent seismologist or blasting consultant proposed for use in conducting pre-blast condition surveys.

(h) Name and qualifications of the independent seismologist or blasting consultant proposed for use in monitoring blast vibration. (See 3.3) A sample of a previous vibration analysis or report or both shall be included with the qualifications. The seismologist or blasting consultant shall be subject to the Engineer's approval.

(i) Listing of instrumentation which the seismologist or blasting consultant proposes to use to monitor vibrations together with performance specifications, instrumentation user's manual supplied by the manufacturer(s). (See 3.3.7)

(j) A complete description of the clearing and guarding procedures that will be employed to ensure personnel, staff, visitors, and all other persons are at a safe location during blasting. This includes details regarding traffic control, visible warning signs or flags, audible warning signals, method of determining blast areas, access blocking methods, how the blaster in charge will communicate with site personnel or other appropriate site supervisory personnel.

(k) A summary of the proper safeguards for personnel in the event of a misfire until the misfire can be re-blasted or safely removed.

(l) Communication protocol between vehicles and office facilities including cease use restrictions during blasting activities.

(m) Proposed vibration monitoring locations.

(n) Predicted PPV values. The scaled distance shall be included and use the following formulas:

$PPV = K(Ds)^m$ 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)

Default values of K = 242 and m = (-1.6) may be used for the equation above. However, K and m are site specific and shall be determined by performing a regression analysis of multiple PPV and Ds data pairs. Proposed K and m values shall be replaced by the site specific values determined after the initial 2 or 3 blasts at each separate blast location, and shall be re-evaluated and adjusted as necessary based on actual site conditions, rock type and structure, subsurface information and blast monitoring measurements.

3.2.2.1 The General Blasting Plan shall form the basis for all blasting operations on the project. If, in the judgment of either the Engineer or the Contractor, changes in the plan appear to be necessary, drilling or blasting operations shall be suspended and a revised plan shall be submitted to the Engineer reflecting the proposed changes. No further drilling or blasting shall take place until approval of the revisions is received from the Engineer.

3.2.2.2 In addition to the General Blasting Plan approval, a site specific Blasting Plan approval will be required for critical locations as deemed necessary by the Engineer or the Contractor. The Site Specific Blasting Plan shall be submitted at least 24 hours before the start of drilling and shall include proposed modifications to the General Blasting Plan requirements listed in 3.2.2. Site specific Blasting Plans may be waived for non-critical areas as determined by the Engineer.

3.2.2.3 Approval of the Blasting Plan shall not relieve the Contractor of full and complete responsibility for the results of the blasting operations. The Contractor also has full responsibility for the accuracy and adequacy of the Blasting Plan when implemented in the field. (See 107.08.)

3.2.3 Responsibility for blasting operations. Review of the Contractor's blasting submittals by the Department or its Engineer shall not relieve the Contractor of its responsibility for the accuracy, adequacy, and safety of the blasting; for exercising proper supervision and field judgment; for preventing damage to structures; or for producing results in accordance with the State of New Hampshire regulations and NHDOT Specifications. The blasting Contractor shall be solely and completely responsible for the safety of all persons and property during the performance of its work. The Contractor shall take whatever measures it deems necessary, in addition to the requirements herein, to protect the safety of persons and property, both at the construction site and away from the site. The Contractor shall have full and complete responsibility for the handling, discharging, or settling of any and all damage or annoyance claims resulting from the blasting activities on the project. Any monitoring and/or review of the Contractor's procedures and performance conducted by the Department or its Engineer shall not relieve the Contractor of its responsibility for safety at and away from the site, or for preventing damage to adjacent structures or property.

3.2.4 Drill hole conditions may vary from dry to filled with water. The Contractor shall be required to use whatever type(s) of explosives and/or blasting accessories necessary to accomplish the specified results.

3.2.5 All space in each blast hole not occupied by the explosive charges shall be filled with stemming material. Stemming material shall be clean stone chips or other approved angular, granular material as shown in Table 1.

Table 1 -- Required Grading of Stemming Material

Sieve Size	Percentage by Weight Passing
3/8 in (9.5 mm)	100
No. 4 (4.75 mm	20 - 25
No. 8 (2.36 mm)	0 - 10

3.2.6 Prior to commencing full-scale blasting operations, the Contractor shall demonstrate the adequacy of the proposed Blasting Plan by drilling, blasting, and excavating short test sections, up to 100 ft (30 m) in length, to determine which combination of method, hole spacing, and charge works best. When field conditions warrant, as determined by the Engineer, the Contractor may be ordered to use test section lengths more than 100 ft (30 m). The Engineer will have the authority to eliminate the test shot(s) if conditions warrant. Requirements for controlled and production blasting operations covered elsewhere in this specification shall also apply to the blasting carried out in conjunction with the test shots.

3.2.7 The Contractor shall not be allowed to drill ahead of the test shot area until the test section has been excavated and the results evaluated by the Engineer. If the results of the test shot(s), in the opinion of the Engineer, are unsatisfactory, then the Contractor shall adopt such revised methods as are necessary to achieve the required results. Unsatisfactory test shot results include an excessive amount of fragmentation beyond the indicated lines and grade, excessive flyrock, and/or violation of other requirements within these specifications.

3.2.8 Blasting Safety

3.2.8.1 Warning signals. Adequate warnings in accordance with OSHA regulation 1926.909 shall be given to all personnel in proximity to the blast site at least three minutes in advance of each blast.

3.2.8.2 Flyrock control. Flyrock shall be controlled through proper blast design. Before the firing of any blast in areas where flying rock or debris may result in personal injury or damage to property, the rock to be blasted shall be covered with approved blasting mats, soil, or other equally serviceable material to prevent flyrock. The method of flyrock control shall be subject to approval by the Engineer.

3.2.9 Controlled Blasting3.2.9.1 Presplitting. Presplitting shall be required in rock slopes where the designed slope is 1:2 (horizontal to vertical) or steeper and the rock is 10 ft (3 m) or more in depth above the subgrade, measured along the slope.

3.2.9.2 Presplitting is defined as the establishment of a free surface of a shear plane in rock by the controlled usage of explosives and blasting accessories in appropriately aligned and spaced drill holes so that the resulting split rock is not affected by subsequent blasting and excavation operations adjacent thereto. (See Figure 1.) The purpose of presplitting is to minimize damage to the rock backslope and to help ensure long-term stability. When presplitting, the detonation of the presplit line shall be before the detonation of any production holes. Production blasting refers to the main fragmentation blasting resulting from more widely spaced production holes drilled throughout the main excavation area adjacent to the presplit line. Production holes shall be detonated in a controlled delay sequence.

3.2.9.3 Prior to drilling, all overburden and all loose and disintegrated rock shall be removed down to solid rock in the vicinity of the presplit lines as shown on the plans. Potentially dangerous boulders beyond the excavation limits shall also be removed as ordered.

3.2.9.4 Presplitting shall extend a minimum of 50 ft (15 m) ahead of the limits of fragmentation blasting within the section, unless otherwise permitted.

3.2.9.5 Unless otherwise approved, holes not greater than 3 in (75 mm) in nominal diameter, and spaced 36 in (1.0 m) on center, shall be drilled along the presplit line and at the required slope inclination to the full depth of the cut or to a predetermined stage (lift) elevation. The proper angle of drilling shall be maintained at all times so that each presplitting hole is parallel to its adjacent one and does not deviate more than 1 ft in 35 ft (300 mm in 10

m), either in the plane of the specified slope line or in its vertical alignment. The toe of the completed slope shall coincide, within those limits, with the toe of the slope shown on the plans. All drilling equipment used to drill presplit holes shall have mechanical or electrical devices affixed to the equipment to accurately determine the angle at which the drill steel enters the rock, unless alternate methods for aligning the drill steel are approved by the Engineer.

3.2.9.6 The spacing of the blast holes specified above, the distribution and type of explosives, methods of detonation, and blasting techniques specified below shall be adjusted as necessary according to the breakage characteristics and structure of the bedrock encountered so as to presplit the rock along the required face.

3.2.9.7 Presplitting holes shall not exceed 35 ft (10 m) in depth unless permitted. Rock deeper than 35 ft (10 m) shall be presplit in lifts, but no lift shall be less than 10 ft (3 m) in depth. Should the Contractor desire to forego presplitting in lifts, the Contractor shall propose it as part of the Blasting Plan, stating specific reasons for blasting at depths greater than 35 ft (10 m) in one lift. If approved, the approval shall be on a trial basis. The first 50 ft (15 m) of presplitting greater than 35 ft (10 m) in depth will be reviewed by either of the methods described in 3.2.9.9, but preferably by excavation and exposure. Further presplitting will not be allowed until the trial section has been reviewed to the Engineer's satisfaction. Subsequent presplitting will occur in this manner, with each section being no greater than 50 ft (15 m), throughout the sections where presplitting holes exceed 35 ft (10 m) in depth. No payment will be made for additional excavated quantity caused by offsetting of presplit holes beyond the specified presplit lines in the top or successive lifts. Presplitting holes in successive lifts shall be designed to offset 2 ft (600 mm) inside of the previously presplit face.

3.2.9.8 Before placing the charge, each hole shall be inspected and tested for its entire length to ascertain the possible presence of any obstructions. No loading shall be permitted until the hole is free of all obstructions for its entire depth. All necessary precautions shall be exercised so as to prevent debris from falling into holes prior to loading and so that the placing of the charge does not cause caving of material from the walls of the hole.

3.2.9.9 Results of presplitting shall be exposed for the Engineer's examination and evaluation. Based upon the Engineer's judgment of results obtained during the progress of the excavation, changes ordered in drilling or blasting methods shall be implemented by the Contractor. If the presplit face is not going to be exposed for immediate inspection and evaluation, the Engineer may require the results of a bore hole deviation measuring survey to verify the proper spacing and orientation of the presplit holes.

3.2.9.10 Continuous column cartridge explosives manufactured especially for presplitting shall be used for all presplitting. The maximum diameter of explosives used in presplit holes shall not be greater than one-half the diameter of the presplit hole, unless otherwise approved. The bottom charge of a presplit hole may be larger than the line charges but shall not be large enough to cause overbreak. The upper portion of all presplit holes, from the top most charge to the hole collar, shall be stemmed. Unloaded and unstemmed guide holes (gas release holes), when used between presplit holes, shall be drilled in the same plane and to the same tolerance as the presplit holes. The guide holes shall extend the full depth of the lift, unless otherwise permitted.

3.2.9.11 If presplitting charges are fired with detonating cord, the cord shall extend the full depth of each hole. If full or fractional portions of dynamite cartridges are used with detonating cord, the dynamite shall be securely affixed to the cord.

3.2.9.12 All presplit holes may be detonated simultaneously or delayed providing the hole to hole delay is no more than 25 milliseconds. The detonation of presplit charges shall precede the detonation of adjacent fragmentation charges within the section by a minimum of 25 milliseconds.

3.2.9.13 The line of blast holes immediately adjacent to the presplitting slope holes shall be drilled 4 ft (1.2 m) from and on a plane approximately parallel to the plane of the presplitting slope holes. No portion of these holes or any other blast holes shall be permitted closer than 4 ft (1.2 m) to the presplit lines. All precautions as necessary shall be taken so as to avoid fracturing the rock beyond the presplit face.

3.2.9.14 The Engineer may order the discontinuance of the presplitting operations when the rock formation is of such character that no apparent advantage is gained.

3.2.9.15 The Contractor may use cushion (trim) blasting if conditions warrant it and if, in the opinion of the Engineer, satisfactory results are obtained during the test shot(s). Cushion blasting is similar to presplitting except that the detonation along the cut face shall be performed after the detonation of all production holes. Difference in delay time between the trim line and the nearest production row shall not be greater than 75 milliseconds nor less than 25 milliseconds. With the exception of the above criteria, requirements previously given for presplitting shall also apply to cushion blasting.

3.2.10 Rock Excavation Record Keeping

3.2.10.1 Blasting log. A blasting log must be completed daily for every primary blast, and copies must be provided to the Engineer. An example of a typical blasting log is shown in Figure 3. The drilling Contractor may use a different format for its blasting log if it has been approved by the Engineer.

3.2.10.2 Within 24 hours following each blast, the Contractor shall submit to the Engineer in writing the following items:

(a) Details of the shot shall include the information shown on the sample blasting log (See Figure 3).
(b) Results of blast monitoring at each instrument location and distance from the blast, including PPV in inches per second (millimeters per second), as well as a copy of the strip chart recording for each monitoring location, marked with the date, time, location of the equipment, and signature and name of seismograph operator.

3.2.11 Best Management Procedures for blasting. The contractor shall follow Best Management Procedures (BMP's) to include preparing, reviewing and following an approved General Blasting Plan; proper drilling, explosive handing and loading procedures; observing the entire blasting procedures; evaluating blasting performance; and proper excavation, stockpiling, processing and use of blasted rock. Best Management Procedures will be considered subsidiary to all rock excavation items.

3.2.11.1 Loading practices. The contractor shall utilize the following loading practices to minimize environmental effects:

a) Blastholes shall be drilled within one foot of the intended blast pattern.
b) Blastholes shall be within five (5) degrees of the intended orientation.
c) Blasthole boring logs shall be maintained by the driller and communicated directly to the blaster. The logs shall indicate depths and lengths of voids, cavities, and fault zones or other weak zones encountered as well as groundwater conditions.
d) Unpackaged/unsleeved ANFO and emulsions shall not be used if artesian or water flowing conditions are encountered.
e) Loaded explosives shall be detonated as soon as possible and shall not be left in the blastholes overnight.

3.2.11.2 Ammonium Nitrate and Fuel Oil (ANFO). The following BMP's shall be followed to reduce nitrate impacts when ANFO is used:

a) Identify blastholes containing water and remove water prior to loading with ANFO.
b) Water resistant ANFO (ANFO-WR) shall be used in blastholes that recharge with groundwater and remain wet even after pumping.
c) Spills of ANFO or other blasting agents, at the ground surface around the blasthole collars shall be cleaned up promptly and either reused or taken off site.
d) Adequate unloaded collar lengths shall be established to reduce both "blowback" when loading pneumatically and blasthole proximity effects.
e) Proper "standoff" distance and loading vessel pressure shall be maintained to reduce "blowback" during pneumatically loading ANFO.
f) Partially used bags of ANFO shall be resealed and returned to the explosive magazine.
g) Loading equipment shall be cleaned in an area where the water can be properly contained and handled in a manner that prevents releases.
h) Explosives shall only be delivered to the site in approved magazine trucks and should not be stored overnight on-site.

3.2.11.3 Bulk emulsions and slurry/watergel explosives. The following BMP's shall be followed to reduce nitrate impacts when bulk emulsions or slurry/watergel explosives are used:

a) Spills of the product shall be removed from the spillage area, and either reused or taken off site for disposal.
b) Proper loading techniques shall be followed when loading a bulk product into a wet blasthole. The bulk liquid product should be extruded into itself from the bottom of the blasthole and not into the standing water above the product.
c) If groundwater conditions are severe, e.g., artesian/flowing conditions, packaged explosives (emulsions, watergels, slurries, blends, cartridged, etc.) shall be used instead of bulk products or as required by the Engineer.

3.2.11.4 Blasthole stemming. The following BMP's shall be followed when placing stemming in blastholes:

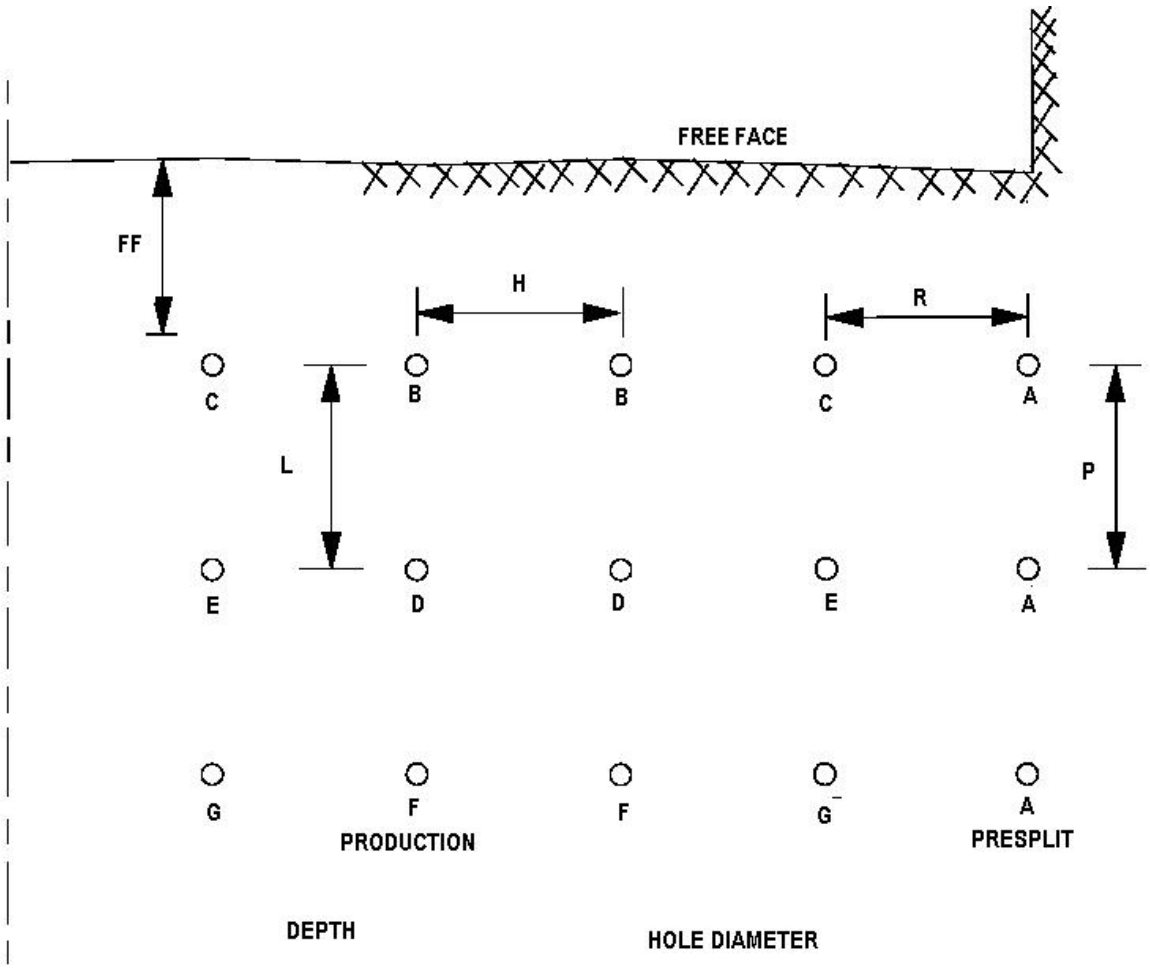
a) Blastholes shall be cleaned out thoroughly using the compressed air stream from the drill to remove the drill cuttings.
b) Drill cuttings shall not be used as stemming.
c) Stemming shall be placed to prevent bridging, and shall be appropriately sized for the blasthole diameter.
d) Blastholes shall be completely stemmed to prevent incomplete detonation.
e) Weak zones, voids, and cavities shall be stemmed as decks to prevent the loss of explosive products into the bedrock.

3.2.11.5 Misfires. One or more of the following BMP's shall be followed to help prevent misfires:

a) Use of redundant surface delays to connect blastholes if shifting mats, uneven terrain or other conditions could cause cut-offs.
b) Double or triple priming of the blastholes.
c) Use of an electric detonating system.
d) Use of a programmable electronic detonating system.
e) Or a method proposed by the Contractor.

3.2.11.6 Fragmented blast rock excavation, handling, stockpiling, processing and use. The following BMP's shall be followed when excavating, handling, stockpiling, processing or using blasted rock fragments on site.

a) Remove the blasted rock (muckpile) from the blast area immediately after blasting.
b) Distribute rock fragments and processed blasted rock widely throughout the project in fill areas as soon as possible.
c) If the blasted rock will not be reused on site, remove the muckpile/processed rock from the project site as soon as possible.



DEPTH

TO _____ **ft (m)**
OVER _____ **ft (m)**

HOLE DIAMETER

_____ **inch (mm)**
_____ **inch (mm)**

PATTERN DIMENSIONS, FEET (METERS)

P = _____ft (m): PRESPLITTING HOLE SPACING
R = _____ft (m): FRONT ROW OFFSET
H = _____ft (m): SPACING PARALLEL TO FREE FACE
L = _____ft (m): SPACING PARALLEL TO PRESPLIT FACE
FF = _____ft (m): DISTANCE TO FREE FACE

CAP DELAYS (NO.)

A = (CAP NO. 0,1,2,3, ECT.)
B =
C =
D =
E =
F =

FIGURE 1 – TYPICAL BLASTING PATTERN

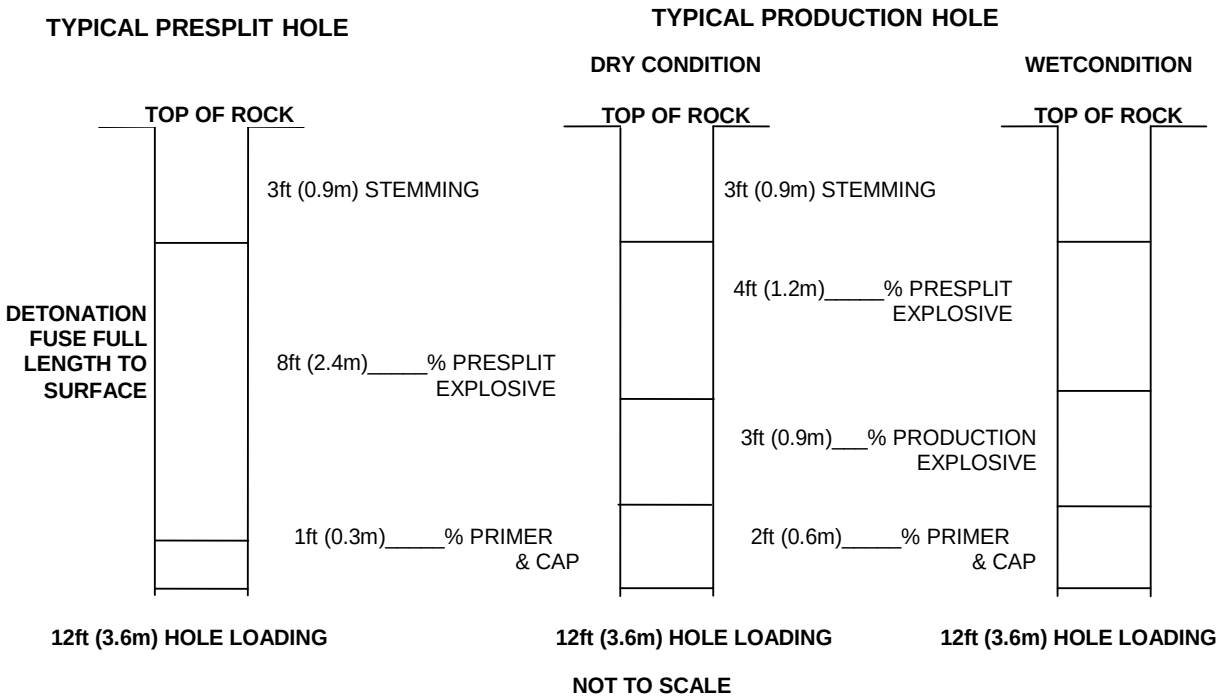


FIGURE 2 – SAMPLE LOADING PLAN

Note: All dimensions, configurations, and loadings shown are intended only as examples of diagrammatic description and should not be construed as indicating any suggested drilling or loading plan.

FIGURE 3

BLASTING LOG English (metric)

NHDOT Project Name_____

Federal Project No. _____ State Project No._____

1. Company Name:_____
2. Location of Shot (Stations): _____
3. Shot Number: _____ 4. Time: _____ 5. Date: _____
6. Weather: _____

   _____

7. Wind Direction: _____ 8. Temperature: _____
9. Distance & Direction to Nearest Structure: _____& _____
10. Depth of Water - Ft (m): _____
11. Total Explosives Allowed Per Delay Period:

    Weight of Explosive(s) (lb) = $\left[\frac{\text{Distance in Feet}*}{50}\right]^2$ = _____

    Weight of Explosive(s) (kg) = $\left[\frac{\text{Distance in Meters}*}{164}\right]^2$ = _____

    * Distance is to the nearest structure.

12. Diameter of Holes - in (mm): Production _____ Presplit _____
13. Depth of Holes - ft (m): _____
14. Total Number of Holes:_____
15. Drill Pattern – Burden times Spacing - ft (m): _____
16. Type and Height of Stemming - ft (m): _____
17. Depth of Sub-Drilling - ft (m): _____
18. Mats or Other Protection Used: _____
19. Types of Explosive(s) Used: Presplit _____

    Production_____

20. Density of Explosive(s) Used:_____
21. Kind of Delay Periods: _____
22. Total Number of Delay Periods: _____
23. Length of Delay Periods (milliseconds): _____
24. Total Amount of Explosives Used - lbs (kg):_____

25. Maximum Number of Holes Per Delay Period: _____

26. Maximum Amount of Explosive(s) Per Delay Period – lbs (kg): _____

27. Powder Factor = $\frac{\text{Pounds of Explosives Per Hole}}{\text{Cubic Yards of Rock Per Hole}}$

    Powder Factor (lbs/yd^3) = _____

    Powder Factor = $\frac{\text{Kilograms of Explosives Per Hole}}{\text{Cubic Meters of Rock Per Hole}}$ x (0.593)

    Powder Factor (kg/m^3) = _____

28. Scale Distance = $\frac{\text{Distance in Feet}}{\sqrt{\text{Weight Per Delay Period in Pounds}}}$

    Note: Formula to calculate scale distance has no metric equivalent.

29. Method of Firing: _____

30. Number of Series Circuits: _____

31. Location of Seismograph: _____

    _____

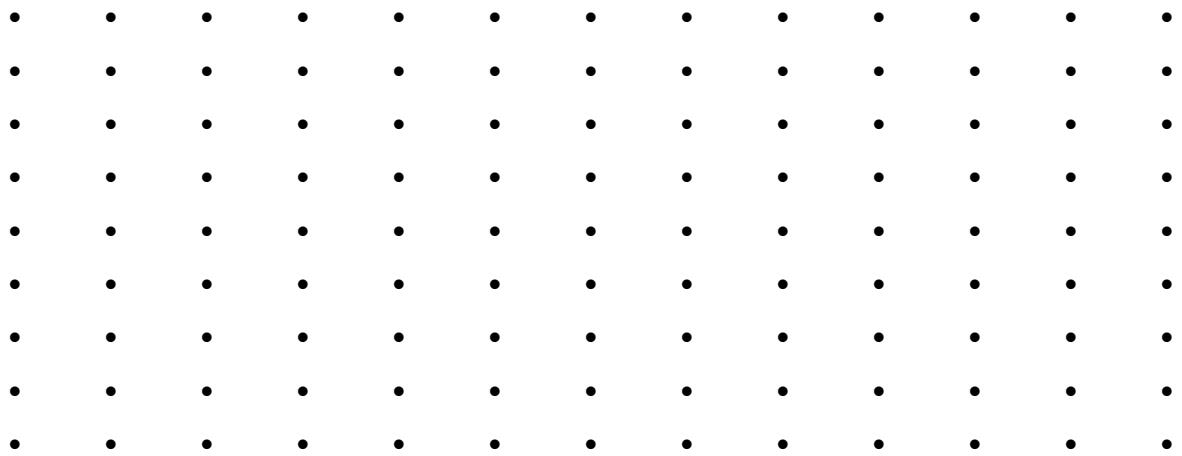
    a. Distance from Shot and Direction: _____
    b. Person Taking Reading: _____
    c. Seismograph Reading: _____
    d. Peak Sound Pressure Levels: _____
    e. Vibration Measurements: _____

    Transverse

    Vertical

    Longitudinal

DIAGRAM OF SHOT



Name of Blaster: _____

License Number of Blaster:_____

3.3 Blast vibration control and monitoring. The Contractor shall be required to comply with the blasting vibration limits established herein. The vibration limits shall be incorporated in the Contractor's Blasting Plan, as required. The Contractor shall provide for monitoring of the blasting vibrations (both ground and air concussions) produced as a result of the construction activities and shall provide Pre-Blast Condition surveys of structures. The Contractor shall cooperate in adjusting the Blasting Plan and procedures to maintain the vibration limits specified herein and to minimize vibration-related claims and complaints.

3.3.1 Seismologist or Blasting Consultant. The Contractor shall retain a seismologist or blasting consultant to monitor, record, analyze, and report the seismic vibrations being caused by blasting activities. The name and résumé of qualifications of the seismologist or blasting consultant shall be submitted to the Engineer for approval no later than the preblast meeting. No drilling or blasting shall take place until such approval is given. The seismologist or blasting consultant shall not be an employee of the Contractor, Subcontractor, explosives manufacturer, or explosives distributor.

3.3.2 Seismologist or Blasting Consultant qualifications. The seismologist or blasting consultant shall be experienced in the subject of vibrations emanating from blasting activities. The seismologist or blasting consultant shall be qualified to thoroughly analyze seismic parameters of the energy source, the energy transmission path, the recording site, and the ground motion spectra. The minimum qualifying requirement to perform the necessary documentation and analysis is a Bachelor of Science degree with accredited course work in at least three of the following disciplines: Seismology, Geophysics, Geophysical Data Processing, Geomechanics, Geophysical Engineering, Vibration Engineering, Soil and/or Rock Mechanics, Foundation and/or Explosive Engineering, Advanced Calculus, and Time-Series (Fourier) Analysis.

3.3.3 Seismologist or Blasting Consultant duties. The seismologist or blasting consultant shall direct and instruct the Contractor in its operations to control vibrations within acceptable levels. The seismologist or blasting consultant shall be in charge of making the preliminary blast survey and, unless otherwise permitted in writing, shall be present at the site of the blasting during all blasts. The seismologist or blasting consultant shall provide and use all necessary equipment to observe and record vibrations to ascertain that acceptable levels of vibrations are not exceeded. The seismologist or blasting consultant shall monitor, report findings, and submit recommendations on a daily basis to the Engineer. The seismologist or blasting consultant shall determine the level of observed vibrations attributed to the project's blasting activities and their subsequent effect on surrounding structures. The seismologist or blasting consultant shall make recommendations for vibration limits to protect sensitive equipment and manufacturing processes if limits have not been predetermined. Written justification shall be provided for all recommendations.

3.3.3.1 Pre-blast condition survey. The seismologist or blasting consultant shall conduct a pre-blast condition survey of all existing structures and conditions on the site, adjacent to the site, or in the vicinity of the site. This survey shall extend to such structures or conditions as may be affected by the Contractor's construction operations. As a minimum, condition surveys shall be performed on all structures, including swimming pools and mobile homes, within 500 ft (150 m) of anticipated blasting areas.

3.3.3.2 The pre-blast condition survey shall consist of a written description of the interior and exterior condition of each of the structures examined. Descriptions shall locate any existing cracks, damage, or other defects and shall include such information so as to make it possible to determine the effect, if any, of the construction operations on the defect. Particular note shall be made of evident structural faults and deficiencies, or recent repairs. Where significant cracks or damage exist, or for defects too complicated to document in words only, sketches and photographs shall be taken or a good quality videotape survey with appropriate audio description of locations, conditions, and defects shall be performed to supplement the written description. Pictures and sketches shall be provided with a scale where practical. Prior to the start of work, a copy of the pre-blast condition survey shall be submitted to the Engineer for review.

3.3.3.3 The seismologist or blasting consultant shall give written notice to the owner of the property concerned, tenants of the property, and any representative of local authorities required to be present at the pre-blast survey. The notice shall state the dates on which surveys are to be made. Copies of all notices shall be provided to the Engineer.

3.3.3.4 Report of monitoring results. Following each blast, the seismologist or blasting consultant shall immediately report the measured vibrations to the Engineer. In the event seismic vibrations caused by the Contractor's operations approach the established limits for this project, the Engineer may require the Contractor to modify the blasting operations to reduce the vibrations. If the seismic ground vibration or air concussions or both ground vibration and air concussions caused by the Contractor's blasting operation attain or surpass the established limits, the operations shall cease. Blasting shall not be resumed until measures have been taken to reduce, to the satisfaction of the Engineer, the produced vibrations and/or air concussions below the established limits. The seismologist or blasting consultant should assist the Contractor in the design of the Contractor's blasting to eliminate the problems and to avoid liability claims.

3.3.3.5 Post-blast condition survey. Upon completion of all earth/rock excavation and blasting work, the seismologist or blasting consultant shall conduct a post-blast condition survey of any properties, structures, and conditions for which complaints of damage have been received or damage claims have been filed. Notice shall be given to all interested parties so that they may be present during the final examination. Records of the final examination shall be distributed the same as the original pre-blast condition survey.

3.3.4 Monitoring locations. At a minimum, one seismograph shall be located at the nearest structure or as directed by the Engineer. Up to a total of three seismographs may be required to optimize blast efficiency while achieving vibration control. Additional seismographs may be required for setup at complaint locations.

3.3.5 Ground vibration limits. The ground vibration limits herein are based on published USBM RI8507 alternative blasting level criteria for blasting activities.

3.3.5.1 The maximum peak particle velocity (PPV) of ground vibration, at any of the monitoring locations, in any of the three mutually perpendicular components of particle velocity, for above-ground, residential structures shall be limited based upon the frequency of the blast vibration as shown in the following graph (Figure 4):

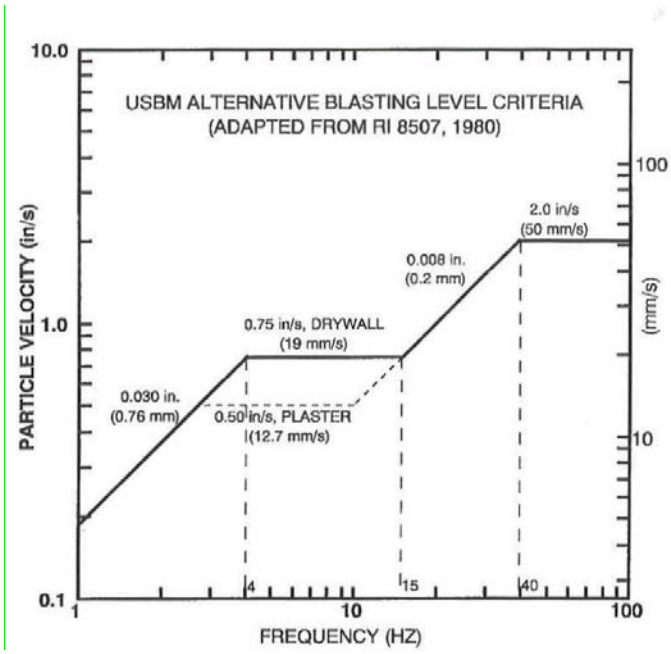


FIGURE 4 - Particle Velocity vs. Frequency United States Bureau of Mines (RI8507, 1980)

3.3.5.2 The maximum PPV of ground vibrations, in any of the three mutually perpendicular components of particle velocity, for non-residential structures shall not exceed 2.0 in/s (50 mm/s).

3.3.5.3 The maximum PPV of ground vibrations, in any of the three mutually perpendicular components of particle velocity, for underground utilities shall not exceed 2.0 in/s (50 mm/s). Buried pipelines and other utilities owned by private utility companies are sometimes subject to lower limiting values imposed by the owner. The Contractor shall verify the maximum allowable PPV of ground vibrations allowed by the individual utilities. If lower limits are required, a special provision describing the limits or conditions required will be included in the proposal. The Blasting Plan and blast design shall be modified accordingly to avoid damage to such utility lines.

3.3.5.4 Deteriorated structures or utilities, structures housing computers or other sensitive equipment, and manufacturing processes that are sensitive to vibrations may require lower PPV limits than stated in this specification. If lower limits are required, a special provision describing the limits or conditions required will be included in the proposal.

3.3.5.5 The Contractor shall not conduct blasting operations within 20 ft (6 m) of newly placed concrete (less than 14 days) without the written approval of the Engineer. For blasting greater than 20 ft (6 m) away from new concrete, the following PPV ground vibration limits apply:

Ground Vibration Limits for New Concrete

Age of Concrete	Maximum PPV, in/s (mm/s)
Less than 3 days	No blasting
After 3 days	1.0 in/sec (25 mm/s)
After 5 days	1.8 in/sec (46 mm/s)
After 7 days	2.0 in/sec (50 mm/s)

3.3.5.6 If blast induced ground vibrations exceed the limits for maximum PPV and modifications to the Blasting Plan cannot achieve vibration levels that fall within the specified limits, then alternative rock excavation techniques shall be required. All non-explosive methods of rock excavation are subject to approval by the Engineer.

3.3.6 Air concussion. The Contractor shall conduct all blasting activities in such a manner that the peak airblast overpressure at all above-ground, occupied structures in the vicinity of blasting does not exceed 134 dB. The air overpressures shall be recorded from each blast and shall be recorded as a linear, unweighted value.

3.3.7 Vibration monitoring instrumentation. All vibration monitoring instrumentation proposed for use on the project by the Contractor shall comply with the following requirements:

(a) Measure, display, and provide a permanent record on a strip chart of particle velocity components.

(b) Measure the three mutually perpendicular components of particle velocity in directions vertical, radial, and perpendicular to the vibration source and produce a real time graphical depiction of the particle velocities recorded for each individual axis for the duration of the event. Additionally, the seismograph(s) shall produce a numeric record of the peak particle velocities and principle frequencies of the vibration recorded for each axis during the event.

(c) Have a velocity frequency response of 2 Hz to 150 Hz, and be capable of measuring PPV of up to 10 in/s (250 mm/s).

(d) All seismographs used on the project shall display the date of the most recent calibration.

(e) Calibration must have been performed within the last 12 months and must be performed to a standard traceable to the National Institute of Standards and Technology.

(f) All instruments and their use shall fully conform to standards published by the Vibration Section of the International Society of Explosive Engineers (ISEE). Seismograph sensors shall be placed so good contact with the ground is achieved and weighted down with sandbags if necessary.