Report

Dyno Nobel

To	Mr. Chad M. Threatt Alamance Aggregates LLC PO Box 552 Snow Camp North Carolina USA 27349
cc	
From	Stuart Brashear Sr. Product and Applications Manager DynoConsult stuart.brashear@am.dynonobel.com
Date	February 22, 2019

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Re: Review of Projected Impact of Blasting on Adjacent Structures for the Proposed Alamance Quarry and Construction Materials Operation.

Mr. Threatt,

As requested, DynoConsult, a value-added division of Dyno Nobel, has reviewed proposed blasting operations associated with the Alamance quarry. The findings of this review are presented for your information.

OVERVIEW

With regard to the location of the Alamance quarry, proposed blasting operations have been assessed with regard to potential impact on three primary structures;

- Nearby non-company owned residential structures
- Colonial Pipeline transmission lines located north of the proposed blast area
- Duke Power high voltage power transmission lines located north of the proposed blast area

Each of these structures will be assessed separately, but prior to any evaluation we must develop a generic or baseline blast design to allow for projecting impact to these structures.

In discussions with management of Alamance Construction Materials and Dyno Nobel, a basic blast design was developed to be implemented for initial blasting to develop the pit. Using Dyno Nobel empirical formulas, the following design was developed to be used as a baseline blasting metrics for the reviews included in this report.

Bench height 30 – 50 feet (Maximum value of 50 feet used for calculations)
Hole diameter – 5.0 inches
Stemming – 10 feet
Bulk Blasting Product – Titan XL™ with average density of 1.18g/cc

Using these metrics, we can calculate a maximum blast hole load of 432 pounds per hole.

It is critical to note that this blast design is in no means the definitive design to be used during the life of mine at Alamance quarry. Production requirements, changes in geology and advances in blasting technology may necessitate modifications from this design. As all blasting will involve seismic monitoring, The blast design is in effect a dynamic process that can be modified to meet changing results and impact on neighboring properties to ensure that there is no impact related to blasting operations.

Blasting will commence at the southern extent of the pit boundary area with subsequent development moving to the north. Given this mine plan, initial blasting will commence as far away as possible from both the Colonial pipelines and the Duke Power transmission lines.

BLAST EFFECTS VARIABLES

In the absence of actual seismic data from blasting, we rely on calculations developed by federal research agencies and accepted industry standards to project blast effects with regard to nearby structures. To project potential vibration levels at adjacent properties and rights-of-way, four metrics are required:

- A reference explosive weight per “delay”
- The distance from the blast to the structure in question
- An attenuation rate for transient ground vibration
- A Y- intercept value for the level of confinement in the blast

The first two variables can be easily sourced based on the blast design and physical location of the blast relative to structures. The last two variables must be based on industry or regulatory standards that have been recommended to allow this type of projection of values.

With the introduction of electronic detonators into the industry, the methodology behind determining the maximum charge value to be used for calculating transient vibration has changed. Previously charge weight values for vibration calculation were based on the USBM Scaled Distance formula which uses a delay window of 8 milliseconds to derive maximum charge weight. With the introduction of precision, programmable electronic detonators, this criterion no longer could be used. The inherent accuracy of the electronic detonator allowed for the use of destructive interference software technology to create timing sequences that actively cancelled vibration created from each hole detonation[1]. This resulted in significantly lower vibration effects even when the calculated charge weight for vibration calculations using the 8-millisecond window increased by several times the normal hole load value[2].

For the purposes of this report, we have defined the maximum explosive charge weight as the maximum charge weight in any given hole in the blast.

The variables related to attenuation and blast confinement have been developed from regression analysis performed on hundreds of blast events by various research groups. In this report, we have used variables developed for three different quarry blast scenarios. Two calculations use variables developed by the United States Bureau of Mines and one is from the Blasters Handbook, 18th Addition. The values that will be used for our assessment are shown on the table below.

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[1] D Anderson, S Winzer, A Ritter, J Reil. “A Method for Site-Specific Prediction and Control of Ground Vibration from Blasting”. International Society of Explosives Engineers 11th Annual Conference on Explosives and Blasting Techniques, San Diego, California 1985.
[2] S Brashear, R Cook. “Diagnosing and Modifying Off-Site Blast Effects by Seismic Means – A Case Study”. International Society of Explosives Engineers 22nd Annual Conference on Explosives and Blasting Techniques, Orlando, Florida USA 1996.

Source	Blast Type	Attenuation Value	Confinement (y intercept)
USBM[3]	Average	-1.38	52
USBM[4]	Worst Case	-1.38	138
ISEE[5]	Average	-1.60	160

Fig. 1 – constants for prediction of ground vibration

COLONIAL PIPELINE RIGHT OF WAY

Concerns over impact on the Colonial Pipeline's gas transmission lines that run through the northern portion of the permit area have been relayed to us. In conversations with Colonial Pipeline representatives, there are two criterion that must be met for Colonial to lend their blessing for blasting operations at the Alamance quarry.

- Measured transient ground vibration at the pipeline right of way must be below 1.0 ips.
- Calculated Scaled Distance values for shot designs must be at a value of 51 or higher to alleviate creating a "Blasting Encroachment" that would trigger the need to reduce transmission pressures in the lines for that given blast.

While all calculations for this report are based on the Colonial Pipeline value of 1.0 ips, it should be noted that this value is significantly below established criteria for the protection of buried pipelines.[6]

Using scaled drawings provided by Alamance Aggregates LLC and confirmed by use of the Alamance County GIS, initial blasting for the quarry will take place approximately 2,675 feet from the Colonial right of

[3] United States Bureau of Mines Bulletin 656. "Blasting Vibrations and their Effects on Structures". Duval, et. al. US Department of the Interior, Washington DC 1971.
[4] United States Bureau of Mines Bulletin 656. "Blasting Vibrations and their Effects on Structures". Duval, et. al. US Department of the Interior, Washington DC 1971.
[5] International Society of Explosives Engineers. "Blasters Handbook". 18th Addition. 2014. Cleveland Ohio
[6] United States Bureau of Mines Report of Investigation RI-9523. "Surface Mine Blasting Near Pressurized Transmission Pipelines. D. Siskind, et. al. US Department of the Interior, Washington DC 1994.

way. Using this distance, and the expected charge weight of 432 pounds per blast hole, the calculated ground vibration, using the values shown above are as shown.

Charge	Distance	SD	PPV	
432	2675	128.701	0.169	**Upper Bounds BU 656 (Quarry Production Blasts Worst Case)**
432	2675	128.701	0.064	**Average BU 656 (Quarry Production Blasts Average)**
432	2675	128.701	0.067	**ISEE Blasters Handbook**

All projected Scaled Distance and PPV values are well below the suggested Colonial Pipeline criteria.

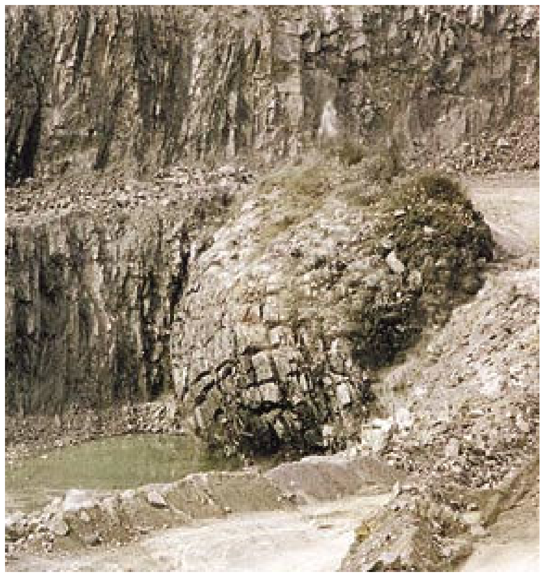
As blasting moves closer to the right of way vibration amplitude is expected to increase. At full maturity, the closest blasting will ever take place with relation to the pipelines will be a distance of approximately 1,175 feet. Modifications to the blast design can be made as required in order to maintain transient vibration levels well below the requirements of Colonial Pipeline. However, even if the proposed initial blast design was to remain static, the expected vibration levels would be.

Charge	Distance	SD	PPV	
432	1175	56.53	0.527	**Upper Bounds BU 656 (Quarry Production Blasts Worst Case)**
432	1175	56.53	0.199	**Average BU 656 (Quarry Production Blasts Average)**
432	1175	56.53	0.251	**ISEE Blasters Handbook**

Again, transient vibration levels and Scaled Distance value remain below the criteria set forth by Colonial Pipeline.

Block Motion

The Colonial Pipeline agent expressed concern over potential block motion impact on the gas transmission lines. Block motion or physical heaving of the rock mass by a blast event in quarry blast operations differs from that experienced for trenching as is utilized for pipeline construction. The presence of a free face, or open space in front of the blast provides the rock impacted by explosives to follow the path of least resistance and move forward into the open pit. The lack of rock movement behind the blast can be seen by the visual observations of the location of the last row of blast holes in the newly created face.



In the picture above, it can be seen that all rock motion from this blast moves outward to open air. There is no disturbance of the material located behind the last row of holes.

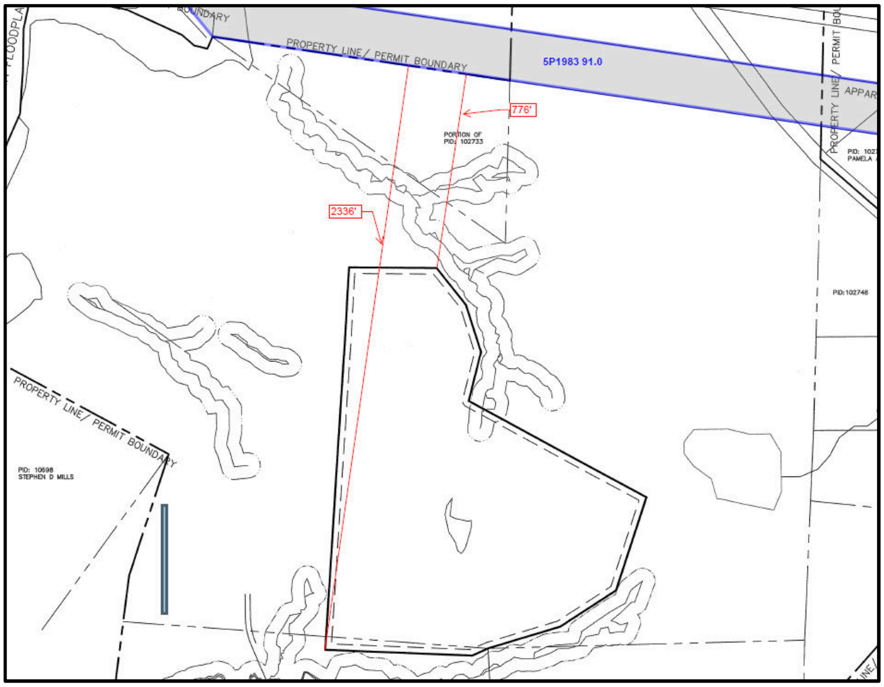
In the picture above, the location of the last row of holes from the preceding shot are clearly evident, showing very little damage and no movement behind the last row of holes in any given blast.
Given the distance from the pipelines to the life of mine extent of mining operations, there is no chance of any block motion impacting the buried pipelines in question.

DUKE ENERGY TRANSMISSION LINES

Duke Energy has provided Alamance Aggregates with guidelines for blasting in the vicinity of transmission towers. While these guidelines are designed primarily for contractor blasting within the transmission line right-of-way (ROW), we can apply them to proposed blasting at the quarry.

- No closer than 150 feet from structure component or guy wire for 500KV or higher lines.
- No closer than 75 feet from structure component or guy wire for 230KV-340KV lines.
- No closer than 50 feet from structure component or guy wire for 44KV – 200KV lines.
- No closer than 100 feet from any angle structure.
- Lattice towers are to be measured from closest structure leg, not center of structure.
- All blasting within 700 feet of any structure shall be monitored with a seismograph.
- Recorded vibration levels shall not exceed 2.0 inches per second (ips).

In again reviewing documents provided by Alamance Aggregates LLC and via the Alamance County GIS, the transmission lines run on an approximate parallel direction to the pipelines and are approximately 350 feet closer to the quarry pit boundary. Calculated distances are 2,336 feet from the initial blasting area and 776 feet for life of mine boundary.



Using a value of 2,336 feet for the distance from initial blasting to the closest transmission tower, the projected vibration values are;

Charge	Distance	SD	PPV	
432	2336	112.39	0.204	**Upper Bounds BU 656 (Quarry Production Blasts Worst Case)**
432	2336	112.39	0.077	**Average BU 656 (Quarry Production Blasts Average)**
432	2336	112.39	0.084	**ISEE Blasters Handbook**

Similarly, using a minimum life of mine distance of 776 feet, we get the following results.

Charge	Distance	SD	PPV	
432	776	37.34	0.934	**Upper Bounds BU 656 (Quarry Production Blasts Worst Case)**
432	776	37.34	0.352	**Average BU 656 (Quarry Production Blasts Average)**
432	776	37.34	0.488	**ISEE Blasters Handbook**

A comparison of the values associated with proposed blasting, both vibration levels and distances from Duke Energy structures shows blast vibration values and distances well within the criteria set forth by Duke Power.

RESIDENTAL STRUCTURES

Significant research has been performed over the decades on the effect of blasting on residential structures. Federal agencies such as the US Bureau of Mines (USBM) and the Office of Surface Mining Reclamation and Enforcement (OSMRE), both agencies of the Department of the Interior, have performed research on the effects of blasting as well as monitored independent research performed by academic institutions and industry sources. As a result of decades of research, a definitive safe blasting criterion was developed by the USBM in 1980 that still is considered internationally and the most effective safe blasting criteria[7]. Attempts at disproving or documenting damage to structures from blasting in accordance with this criterion have never been verified and it is considered statistically a zero percent possibility of damage for blasts that meet this standard.

The criteria developed by the USBM is a variable standard of ground vibration based on the frequency of transient vibration motion. These criteria show allowable peak particle velocity values ranging from 0.50 inches per second to 2.0 inches per second depending on the frequency spectra of the associated ground vibration. This safe blasting standard is graphically shown in the USBM report as the Appendix B Alternative Blasting Level Criteria and is shown below.

[7] USBM Report of Investigations RI-8507. “Structure Response and Damage Produced by ground Vibration From Surface Mine Blasting”. D Siskind, et al. Washington DC 1980.

APPENDIX B.—ALTERNATIVE BLASTING LEVEL CRITERIA

Safe blasting vibration criteria were developed for residential structures, having two frequency ranges and a sharp discontinuity at 40 Hz (table 13). There are blasts that represent an intermediate frequency case, being higher than the structure resonances (4 to 12 Hz) and lower than 40 Hz. The criteria of table 13 apply equally to a 35-Hz and a 10-Hz ground vibration, although the responses and damage potentials are very much different.

Using both the measured structure amplifications (fig. 39) and damage summaries (figs. 52 and 54), a smoother set of criteria was developed. These criteria have more severe measuring requirements, involving both displacement and velocity (fig. B–1).

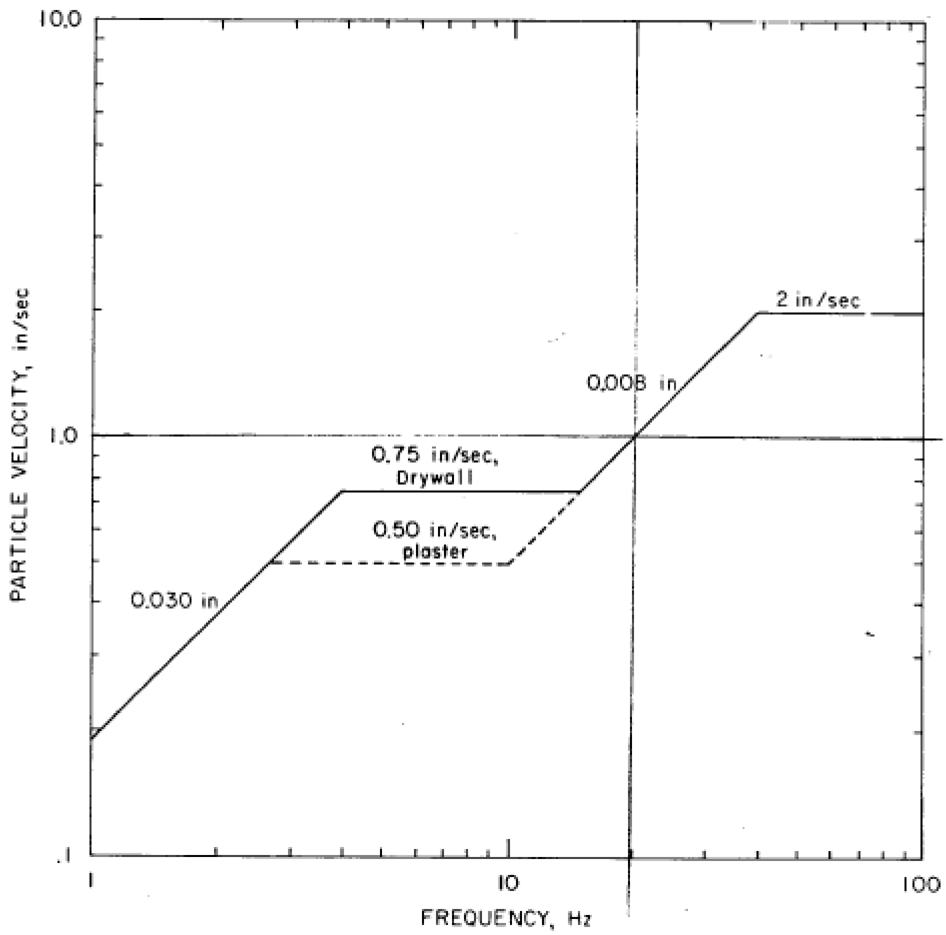


Figure B–1.—Safe levels of blasting vibration for houses using a combination of velocity and displacement.

To show compliance with this standard, which has been adopted by the state of North Carolina for regulated mining operations, seismograph data recorded from blasting events is automatically displayed with the USBM sliding scale. Compliance can be proven by either a review of the ppv values recorded by the unit or by a visual inspection of the blast data as shown with the USBM Appendix B criteria superimposed on the data plot.

The location of the operating pit for the Alamance Aggregates operation is situated in the center of the permitted property in a rural area of Alamance County. As a result, the distances between mining operations (drilling and blasting) remain large. In reviewing data provided by Alamance Aggregates LLC and reviewing via the Alamance County GIS, the following distances and projected vibration levels have been calculated.

Owner	Location	Distance Minimum	PPV Worst	PPV Average	PPV ISEE
Norman Jackson	262 Clark Rd	1,250	0.46	0.17	0.22
Deborah Sanders	8900 Snow Camp Rd	1,800	0.28	0.11	0.12
Timothy Mulrooney	9065 Whitehouse Ct	1,225	0.47	0.18	0.22
Brian Lee	1732 Quackenbush Rd	1,440	0.38	0.14	0.17

This review shows that even using the worst-case blasting environment (heavy confinement) and the worst case USBM safe blasting criteria limit of 0.50 ips (low frequency, plaster on lathe interior), blasting at the closest location to these structures life of mine still indicates vibration levels within the USBM safe blasting standards without any modification from the initial blast design.

SUMMARY CONCLUSIONS

A review of adjacent properties has been performed to determine what, if any impact proposed blasting operations associated with the Alamance Aggregates LLC operation in Snow Camp NC would have on these locations. Using established safe blasting criteria and results of recent studies and investigations DynoConsult can find no evidence that proposed blasting at this location will have any impact on adjacent structures as outlined in this report, even when the mine operation reaches full life of mine dimensions.

Review of proposed criteria for the protection of the Colonial Pipeline ROW and the Duke Energy ROW have been compared to projected blast vibration values. All calculations lead to evidence that blasting poses no threat to either Colonial Pipeline or Duke Energy structures located in proximity to the Alamance Aggregates LLC mining plan.

Should you have any questions or require additional information regarding information contained in this report, please do not hesitate to contact me at any time.

Respectfully submitted,

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APPENDIX 1

Charge weight per foot calculator

$$Chg\ wt = (hole\ diameter^2)x\ product\ density\ x\ 0.3405$$

Chg. wt. per foot = $(5.0)^2$ x 1.18 x 0.3405

Chg. wt. per foot = 25 x 1.18 x 0.3405

Chg. wt. per foot = 10.04 lbs./loaded foot

Charge weight per hole

$$Chg\ wt\ per\ hole = (face\ height + subdrill - stemming)\ x\ 10.04$$

Chg. wt. per hole = (50 + 3 – 10) x 10.04

Chg. wt. per hole = 43 x 10.04

Chg. wt. per hole = 432 lbs.

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APPENDIX 2

Blast design calculations

Shot Specific Data	
Actual Burden	13
Actual Spacing	13
Bench Height	50
Decks (total ft)	0
Stemming	10
Subdrill	3
Rock Density	2.7
tons per yard	2.274
Explosive Density (avg)	1.18
Energy (cal/g)	680
VOD	17100
Yds/hole	313
Tons/hole	712
Charge/ft	10.04
Charge/hole	432
Powder Factor (tons/lb)	1.65
Powder Factor (lbs/yard)	1.38
energy (kcal/yd)	426.1
total energy (kcal/ton)	187.3

APPENDIX 3

Vibration calculation formula

$$PPV = k\left(\frac{distance\ from\ blast}{\sqrt{chg\ weight/hole}}\right)^{-b}$$

Where K = y axis intercept value

Where -b = slope of vibration attenuation rate

Source	Blast Type	Attenuation Value	Confinement (y axis intercept)
USBM[8]	Average	-1.38	52
USBM[9]	Worst Case	-1.38	138
ISEE[10]	Average	-1.60	160

[8] United States Bureau of Mines Bulletin 656. "Blasting Vibrations and their Effects on Structures". Duval, et. al. US Department of the Interior, Washington DC 1971.

[9] United States Bureau of Mines Bulletin 656. "Blasting Vibrations and their Effects on Structures". Duval, et. al. US Department of the Interior, Washington DC 1971.

[10] International Society of Explosives Engineers. "Blasters Handbook". 18th Addition. 2014. Cleveland Ohio