

FACTORS DRIVING CONTINUOUS BLASTING IMPROVEMENT AT THE LAFARGE RAVENA PLANT

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ABSTRACT

The Lafarge Ravena Cement Plant in Ravena, New York demonstrated continuous and extraordinary improvement in productivity during the past several years. The factors driving continuous improvement at the Lafarge Ravena Plant include:

- 1) Management techniques including regular scheduled and effective Blasting Optimization Team meetings.
- 2) A real time blasting database to guide blasting product and procedure decisions. Key decisions involved all levels of quarry and blasting supplier personnel and a close working relationship between production and blasting areas of expertise was demonstrated.
- 3) Blast optimization and optimization of quarry operating parameters such as blast location relative to crusher location, hours worked, etc.

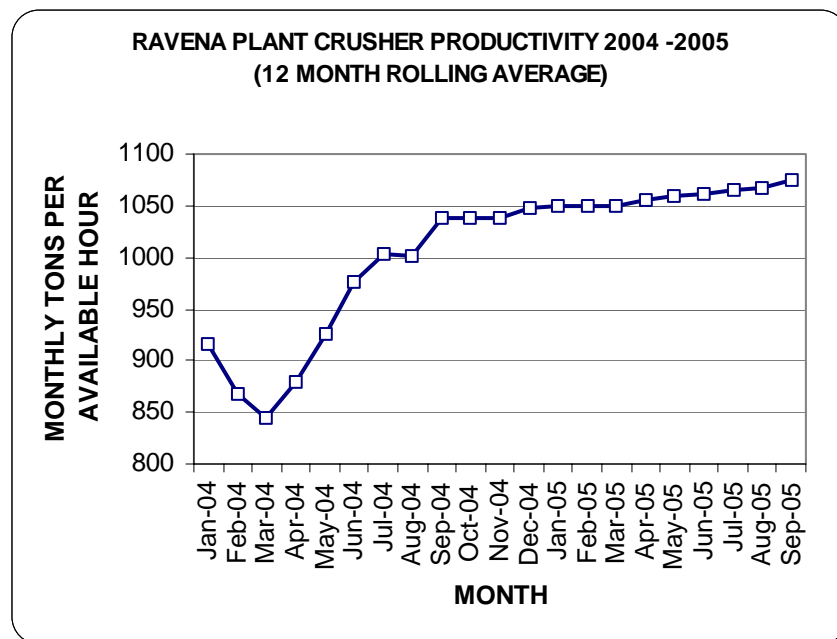
A statistical analysis has been conducted to quantify and understand the effects of blasting changes and other factors to determine the factors involved in productivity improvement.

The statistical methods developed for this analysis and the management techniques described in this report can be used in other locations to guide continuous productivity improvement and achieve operating efficiencies in a wide variety of quarry operations.

INTRODUCTION

The Lafarge Ravena Cement Plant is located in Ravena, New York and has been in operation since 1962. The quarry produces both aggregate and feed to the cement plant. Four million tons will be crushed and 3.7 million tons will be wasted in 2006 for a total of 7.7 million tons. Jim Batterton with Dyno Nobel was in charge of blasting operations for the entire period described in this study. Blasting is conducted using a 6 ½” diameter hole, Fragmax™, miniprills and a variety of initiation systems. The primary crusher is an Allis Chalmers 54 x 74 Gyratory with a 70-ton rock box. The quarry operates a fleet of two Cat 992G loaders and four Cat 777 haul trucks.

The Lafarge Ravena Cement Plant quarry demonstrated continuous and extraordinary improvement in productivity during the past several years as shown below. Two of the co-authors, Dave Bremer and Robert Ethier, were awarded Lafarge’s President’s Award for this achievement.



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BLAST OPTIMIZATION TEAM (BOT)

Regular periodic meetings are held with all involved quarry and blasting personnel to set goals, check on progress towards goals, and adjust key blasting and quarry operations parameters to achieve the goals.

Where possible key benchmarks and indicators are given numerical values. Decisions involved all levels of quarry and blasting supplier personnel and a close working relationship between production and blasting areas of expertise is demonstrated. The results are formalized in a report as shown below. Continual revisiting and confirmation of decisions is a requirement for success.

Criteria:		Work Subject	Date Completed	Responsible Person(s)	Comment(s) & Impact(s):
1	Safety	No accidents			
		No Flyrock			
		Signage, From TIP's			
		Contractor forms, Msfire procedure			
2	Environment	Complaints			
		Tracking			
		Noise , Vibration			
3	Productivity & Quality	Tonnes processed per operated hour			
		Tonnes blast			
		Tonnes crushed			
4	Cost	Explosives Cost per Tonne			ETI Blast database
		Drilling Cost per Tonne			
		Drilling & Blasting Cost per Tonne			
5	Training	ISEE, Practical Blasting Fundamentals Level 1			
		Tips, signoff			
6	Site Objectives	1.			
		2.			
		3.			
		4.			
7	Miscellaneous New Issues				

BLASTING DATABASE

Lafarge and Dyno Nobel have maintained an extensive blasting database, which is continually updated and contains information gathered from all Lafarge North America sites. The database was developed and maintained by Dyno Nobel's Dale Bodnarchuck and has been in existence

since the late 90s. Lafarge coordinated the adoption of a standard shot report for input to the database as shown below.

LAFARGE NORTH AMERICA Blast Report

Property: _____
Blast number: _____

Property Data: date: _____ time of blast: _____ AM PM
rock type: Limestone Granite Other
UTM northing: _____ easting: _____
bench no.: _____ elevation: _____
bench I.D.: _____

Pre blast site inspection: or blank
bench condition: fence at face broken rock? wet?
face condition: overhangs burdens crest fracture
hole deviation monitored? face profiled

comments: _____

Blast Data: production: _____ development: _____
Length Width Depth
dimensions: _____ m _____ m _____ m
volume: _____ m³ density: _____ tonnes/m³
L x W x D x density = tonnes
tonnes: _____
drill contractor: _____ hole diameter: _____ mm
number of holes: _____ rows: _____
average depth drilled: _____ m sub drill: _____ m
average bench height: _____ m total drilled: _____ m
angle holes: yes no degrees: _____
average burden: _____ m spacing: _____ m
stemming: depth: _____ material used: _____
delays / hole or deck: _____ stone decks: no decks m
max kgs / delay or hole: _____ explosives decks: no decks m
Pf. kgs / m³: _____ Pf. kgs / m³: _____
number of holes wet: _____ number dewatered: _____

Post blast / safety comments: _____

Fragmentation
video of blast? yes no
blast complaints? yes no see complaint report

Bulk Products:
product: _____ density: _____
product: _____ density: _____
product: _____ density: _____

Explosives Total kgs.: _____

Atmospheric Conditions:
wind speed: < 20 km/h temperature: _____ deg C
barometric pressure: _____ mbar ceiling: < 600 m

Seismic Data: (closest non Lafarge structure) well no. _____
tech's name: _____ tech. license #: _____
calibration date: _____ trigger level: _____
location: _____ event no.: _____
distance to blast: _____ m scale distance: _____
seismic setup: bolted sandbagged sit tie
PPV (mm/s): transverse: _____ mm/s Hz
PVS (mm/s): vertical: _____ mm/s Hz
longitudinal: _____ mm/s Hz
PSPL (dB Max): _____ PSPL (PSI Max): _____

Explosives utilization: timing type length number
Surface delay: _____
Surface delay: _____
Surface delay: _____
electric cap: _____

Packaged Products: dimension type number weight
nonel tube (m): _____
Sub total: _____ kgs. used: _____
_____ kgs. used: _____
_____ kgs. used: _____

Blasting contractor: _____ Blaster in charge: _____
Crew: _____ License / permit no. (s): _____ Lafarge representative: _____ License / permit no. (s): _____

The standard shot report allows summation of information by region and company wide if desired. Standard reports, including key graphics and trends, are issued monthly and in many cases are the focus of the BOT meetings discussed earlier. Special reports are created from time to time as required. The shot report information can also be outputted in the form of spreadsheets that are used in the statistical studies that follow in this article. Blasting information can be sliced and diced in infinite ways to help the BOTs achieve their goals.

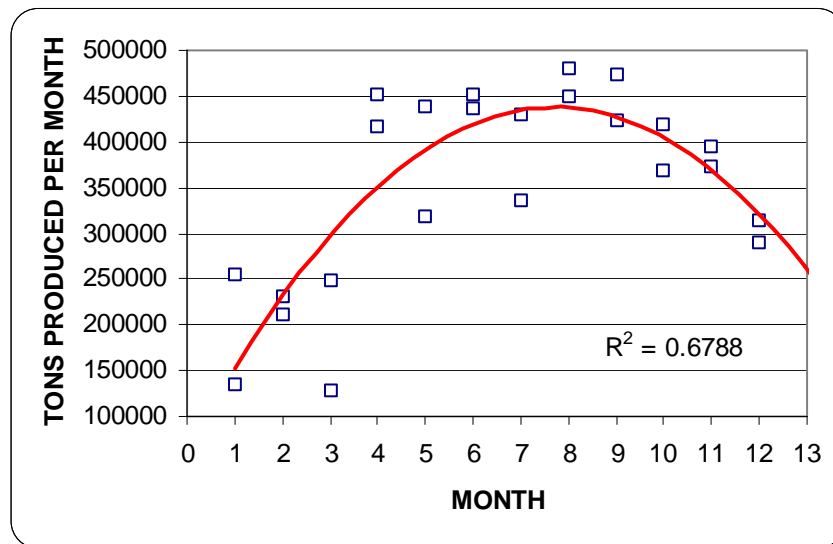
BLASTING AND QUARRY OPERATIONS OPTIMIZATION

The following charts illustrate the types of information that were extracted from the Lafarge Ravenna production database and the Lafarge-Dyno Nobel blasting database. Below are several of the operating parameters must be taken into account when evaluating the effects of changes to blasting parameters. Crusher productivity is defined as tons per available hour.

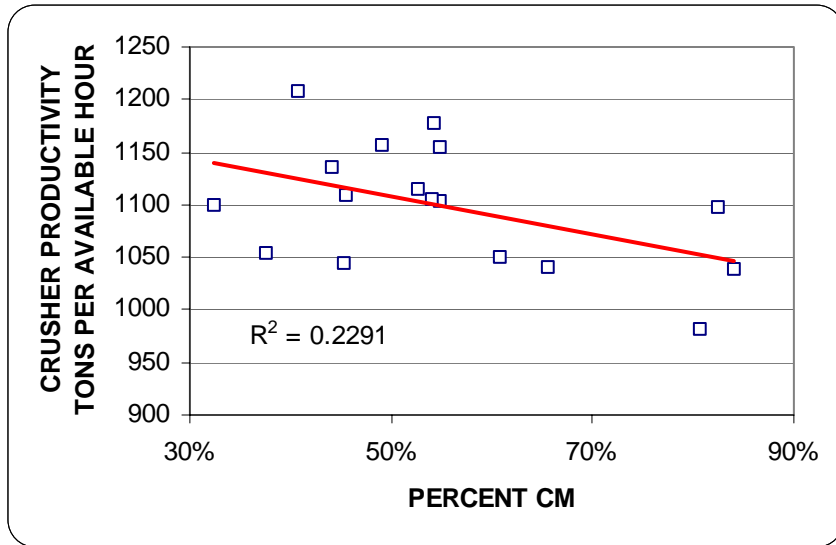
The use of numbers generated in a database by blasts and productivity records to optimize is a daunting but rewarding exercise. A typical increase in productivity resulting from this type of analysis is usually in the range of 5% to 10% with an even greater savings reflected in costs.

There are many nonlinear blasting and production variables, seasonal relationships, site-specific modes of operation, and numerous changes in operational parameters that must be accounted for in any analysis. Nevertheless with enough data, useful information can be extracted. The results right or wrong are usually immediately evident and can form the basis for further work. The results when correct have a huge impact on production rates and overall costs. The methods can also be used to evaluate different types of explosive, initiation systems, etc. A key thing to remember is to try to confirm hypotheses in more than one way if possible before making major changes.

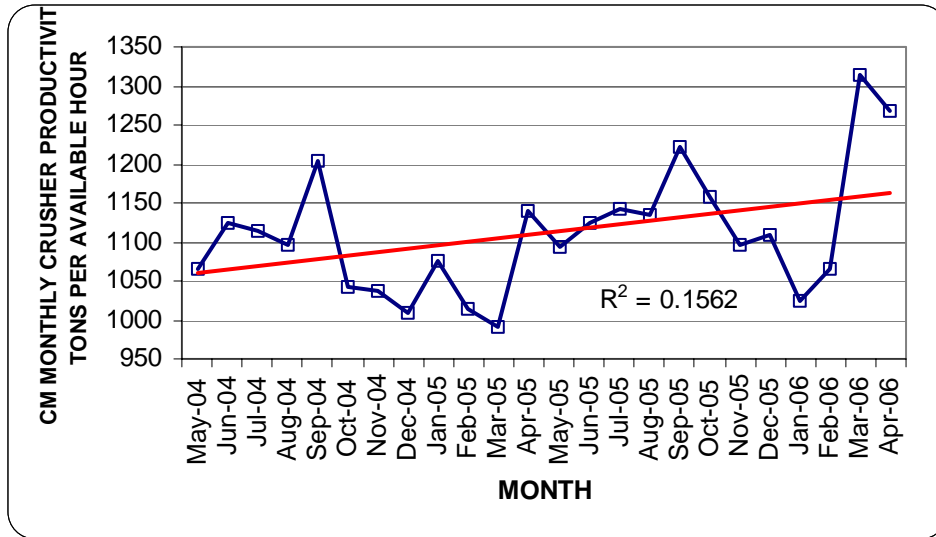
Most quarries are seasonal and production rates as well as total production requirements are affected by weather and seasonal demand for stone, cement and other products. Over a period of years however, trends develop that can be used for future decisions in deciding blasting and production requirements. For example, below is the expected crushing production requirement for the Ravenna operation using data from 2004, 2005, and 2006.



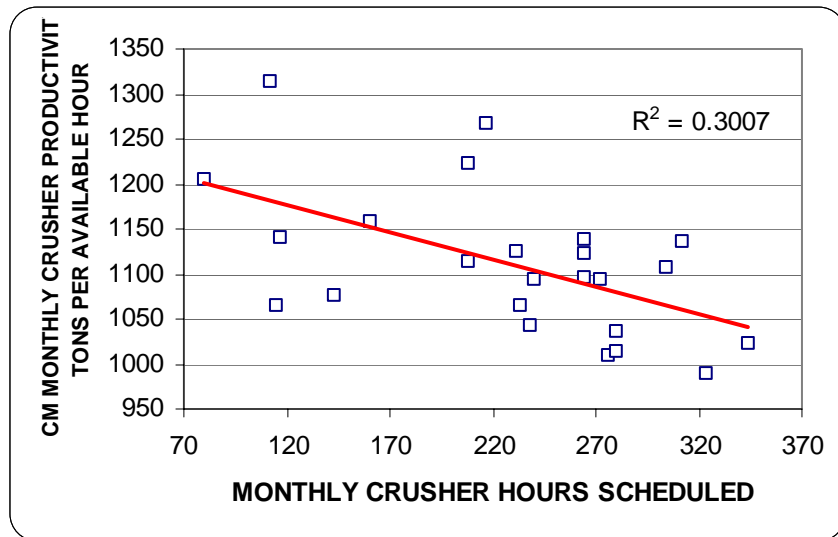
At Ravenna, product is produced for two major purposes, aggregate (AGG) and cement (CM). Aggregate and cement are each blasted in different ways and crushing rates are different. Below is a summary of monthly crushing rates at Ravenna depending upon the mix of aggregate or cement raw material crushed.



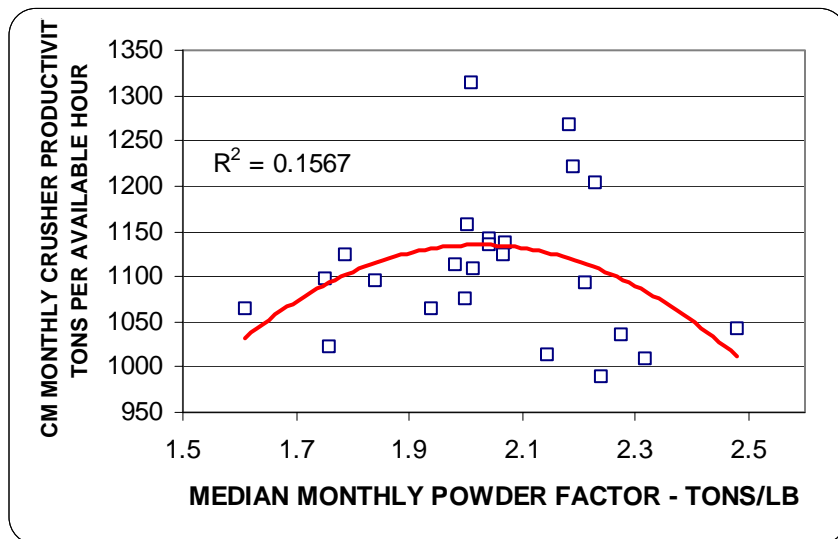
With the information above, the data was sorted to only look at the cement feed blasting and crushing rates as shown in the monthly summary below. The increasing trend is evident and indicates further improvements in March and April 2006.



Another production variable that is key to the analysis is the change in crusher productivity as scheduled hours increase as shown below for cement feed.



The following charts illustrate the types of information that can be extracted from the Ravenna blasting database when combined with the Ravenna production database. Again, the data is limited to cement feed. The first chart illustrates the typical nonlinear relationship between powder factor (tons/lb) and crusher productivity. There is an optimum at approximately 2.0 tons/lb. When powder factors are too high, oversize is created. The crusher chokes with fines when powder factors are too low. The high productivity of the two months in 2006 is evident at close to the optimum powder factor.



To confirm the relationship and optimum point between powder factor and tons per available hour found using monthly data, a graph of the daily relationship was made. While most quarries do not relate the blast to the crushing rate and many blasts can be processed on the same day, with enough data the relationship becomes evident either by using the blast data relative to the crushing rate from blast to blast or for a set period of time. Two factors help this analysis, the fact that powder factors usually are

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While the statistical data analysis can be very time consuming, the sometimes non-intuitive results can be exciting. Several hundred statistical analyses have been performed in North America resulting in productivity improvements of from 5% to 11%. The cost savings resulting from the productivity improvements is an even higher percentage making the exercise extremely rewarding. The techniques illustrated in this paper are expected to be refined and automated in the future to more fully integrate blasting and quarry operations in the future.

“When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.”
LORD KELVIN

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