Stemming Selection for Large-Diameter Blastholes

by
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INTRODUCTION

Since 1990 the Minntac Mine has been testing means of reducing energy loss due to venting through the stemming column. It is felt that each millisecond of increased retention of the bubble energy will result in more work done to the rock mass and will reduce the velocity (and range) of flyrock. The overall goals of the blasting program are to: enhance safety, enhance fragmentation, minimize drilling and reduce powder costs. Simultaneous pursuit of these objectives has brought blast geometry to a configuration where the holes are short and far apart(40-foot benches with 32-foot burdens and spacings. Large blastholes (16-inch)are used to keep the powder factor up with the use of anfo. Lateral movement of the muckpile is undesirable due to the haulage method. Rail haulage requires that passing tracks be maintained on each bench. Therefore, the preceding blast is not mucked out entirely. This remaining buffer further compounds the problem of stemming ejection by restricting horizontal relief.

Picture 1. Concrete plug for 16" hole

SCOPE

Stemming has been defined as the inert material used to backfill a borehole for the purpose of containing the explosive energy and reducing the unwanted effects of airblast and flyrock. The two most discussed features of stemming are particle size and stemming column height. Stemming size has been traditionally selected in accordance with the hole diameter. The stemming height has been selected based on a function of burden. In actual practice, the type of stemming used has been a matter of what was readily available and the height varied in accordance to the burden but was influenced by the powder density (i.e. more stemming where high-density, waterproof products were needed and less stemming where anfo could be used). The limiting factor for minimum stemming was airblast and flyrock considerations. As larger bit sizes became available, burdens were increased which in turn required more stemming to control violence. This evolution has brought designs to where a 40-foot borehole has 20 feet of stemming, where a 1.36 specific gravity product is used, or 16 feet of stemming where anfo is used. This 16 to 20-foot collar region of the blast is the primary source of oversize material, especially in caprock conditions.

With the advent of reliable instrumentation, it is now possible to measure the effects of stemming practices including concrete plugs and air decks.

1. Three sizes of stemming material.(see fig 1,2 &3)
a. coarse tailings (minus 3/8 inch)
b. mill feed (minus 3/4 inch)
c. ballast (minus 2-3/4 inch)

2. Poured and pre-cast concrete plugs in stemming column
3. Air gaps at top of powder column.

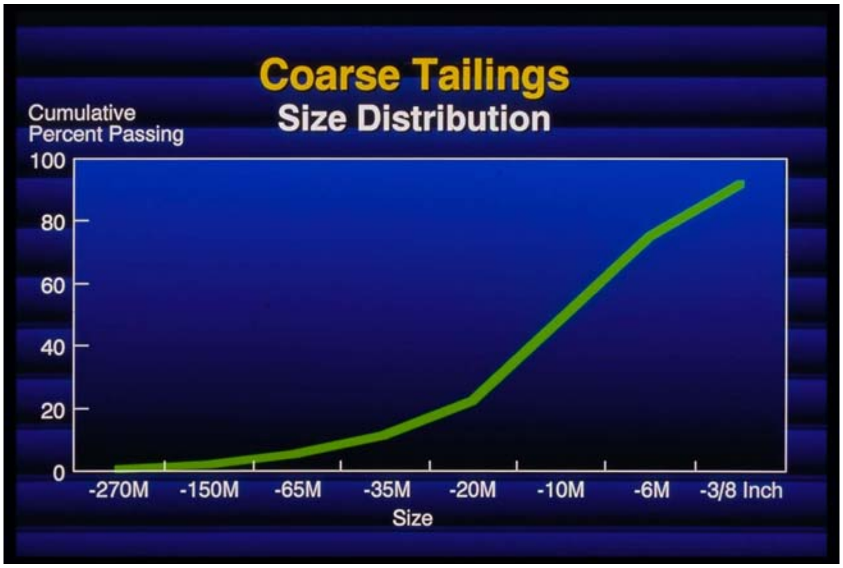


Figure 1. Normal fine stemming

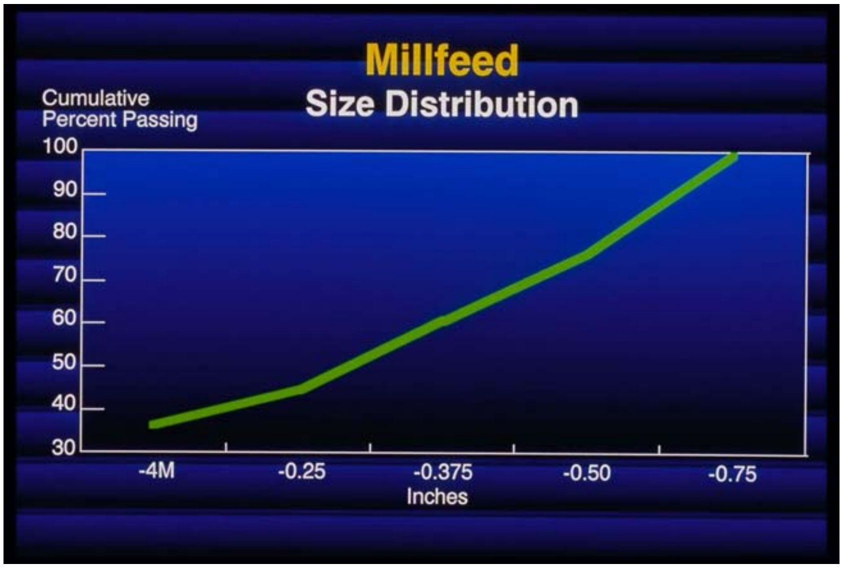


Figure 2. Medium size test stemming

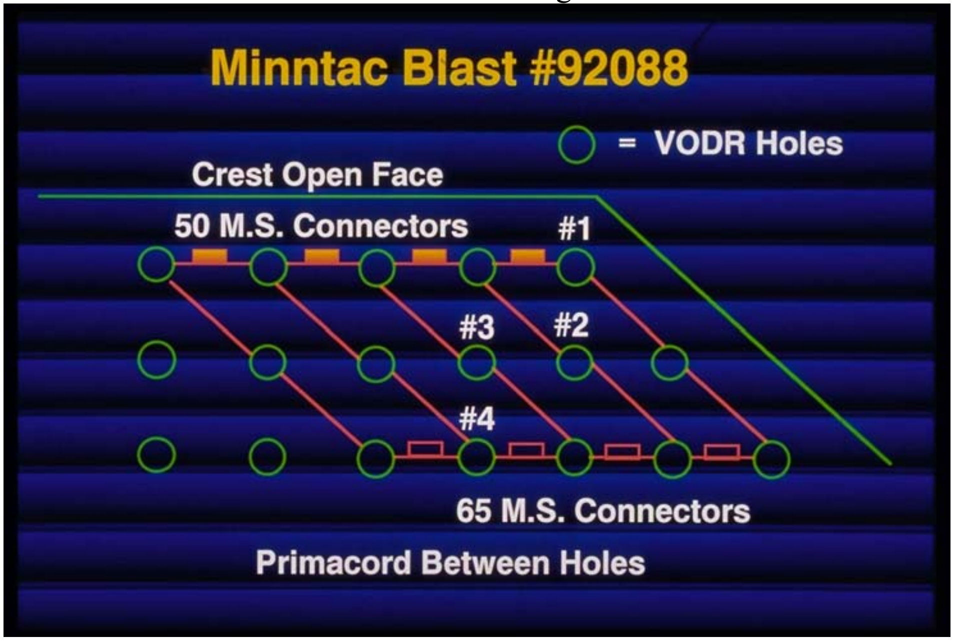
Figure 3. Coarse test stemming

The following methods have been used to evaluate the efficacy of stemming changes.

1. Down stream parameters:
a. Diggability
b. Crusher throughput
c. Crusher amperage
2. Size analysis from digital image analysis
3. High-speed filming ejection velocity
4. VODR - stemming retention time

Velocity of Detonation Recorder (VODR)

A velocity of detonation recorder was used to measure stemming retention time. Two channels simultaneously measure powder column velocity and hole collar cutoff. Blast 92088 had four holes with coaxial cable in the powder column and in the collar. It was felt that precise initiation time could be referenced to the cutoff of the second channel which measured the release of the stemming.



Minntac Blast #92088

Figure 4. VODR test holes

Minntac Blast #92088

One 350 M.S. Delay Attached To 1# Primer In Each Explosive Deck Row
Of Holes Tied Together With 25 Gr. Primacord

Figure 5. Section view of VODR test

Figures 4 and 5 show the plan and section views of the vodr test. Figure 6 is the time history of the crushing of the coaxial cable in the holes.

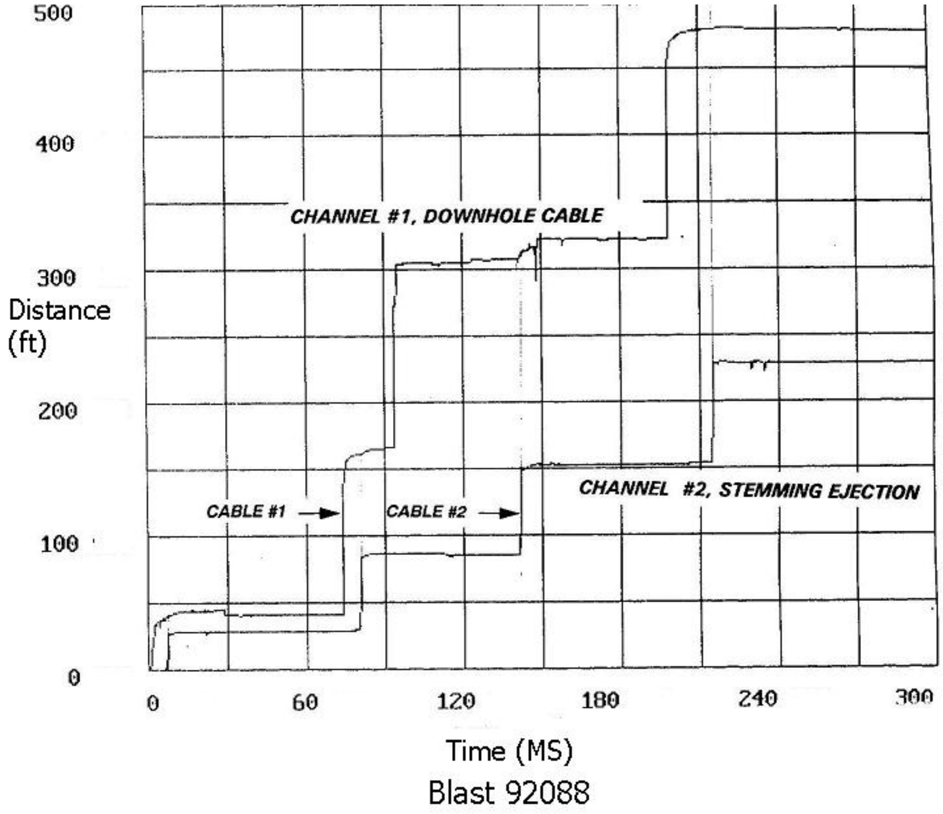


Figure 6. VODR record

The 'holding times' of the stemming were as follows:

Hole 1 7.28 milliseconds
Hole 2 5.06 milliseconds
Hole 3 0.28 milliseconds
Hole 4 15.22 milliseconds

Further examination of these records seemed to indicate that these were not retention times. The coaxial cable in the collar probably was crushed well ahead of actual stemming ejection. Past estimates of retention have been in the order of 30 to 40 milliseconds. The wide variation in cable crushing times for holes 3 and 4 probably reflect the high degree of preconditioning taking place as nearby holes fire. If severe distortion of the powder column is already taking place with 50 millisecond delays, plans for longer delay times may be inappropriate.

EJECTION VELOCITY

Blast 93027 tested four types of stemming columns. A Red Lake LO-Cam filmed the blast at 500 frames per second. Stemming displacement was then scaled at 20 millisecond (10 frame) intervals. Figures 7 and 8 show the plan and section view of the test zones.

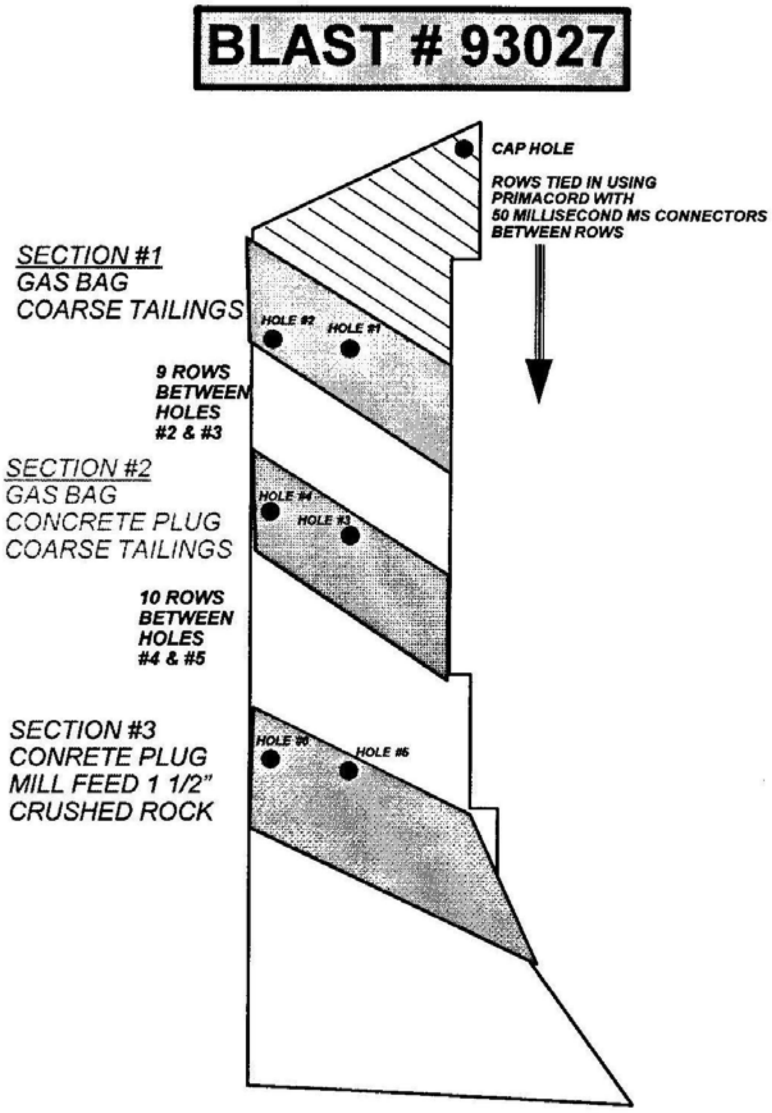


Figure 7. Layout of stemming test

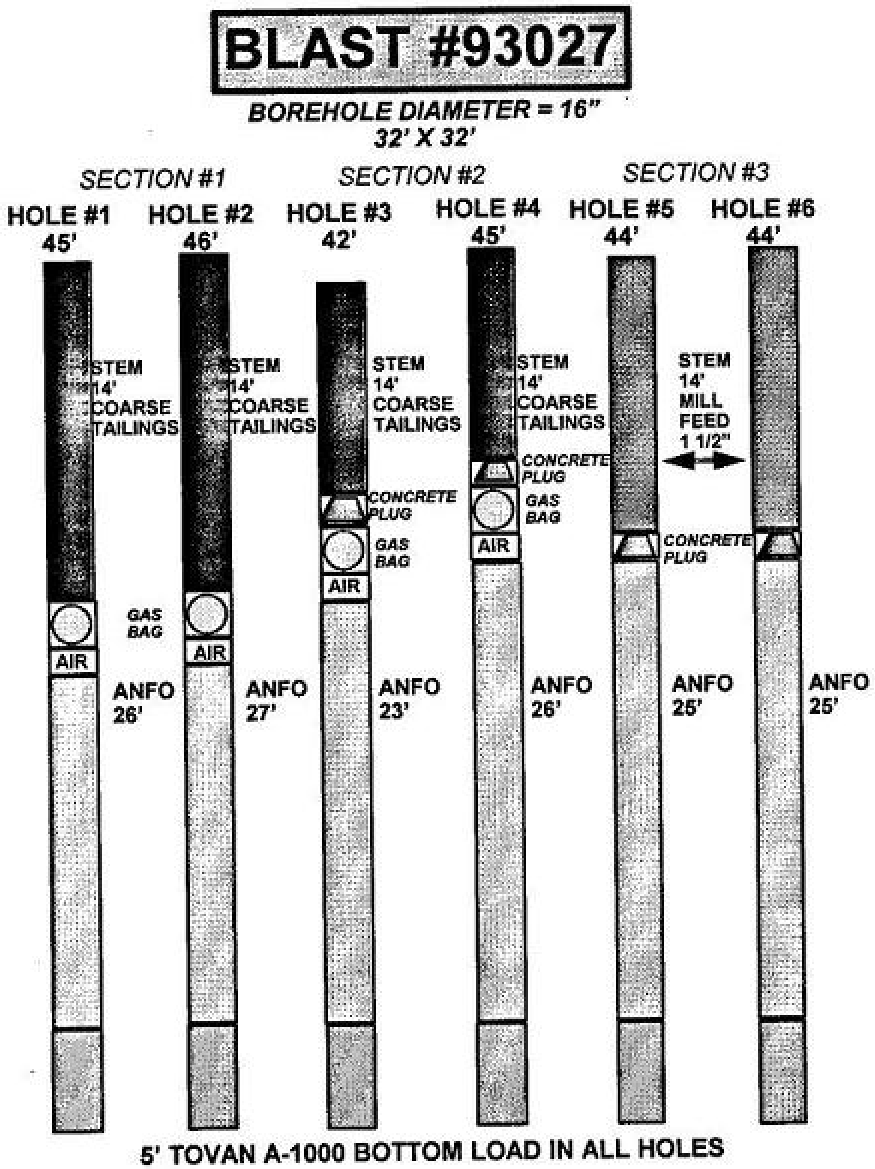


Figure 8. Section view of stemming test

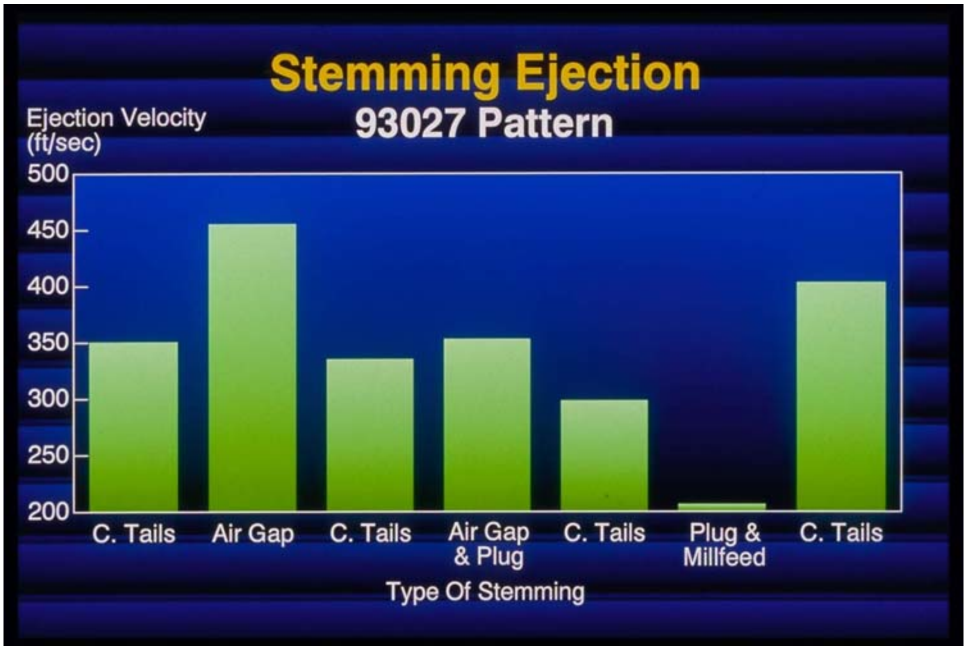


Figure 9. Ejection velocities

Figure 9 shows the ejection velocities. The highest velocities were associated with the air gaps where there was two feet less of stemming. The lowest velocities were the holes using millfeed (minus 3/4-inch) and pre-cast concrete plugs. The same type of analysis was applied to blast 92041 which compared ballast, ballast with concrete plugs and the normal stemming consisting of coarse tailings. The results are summarized in figure 10. Ejection velocites drop as much as 40% where plugs are used.

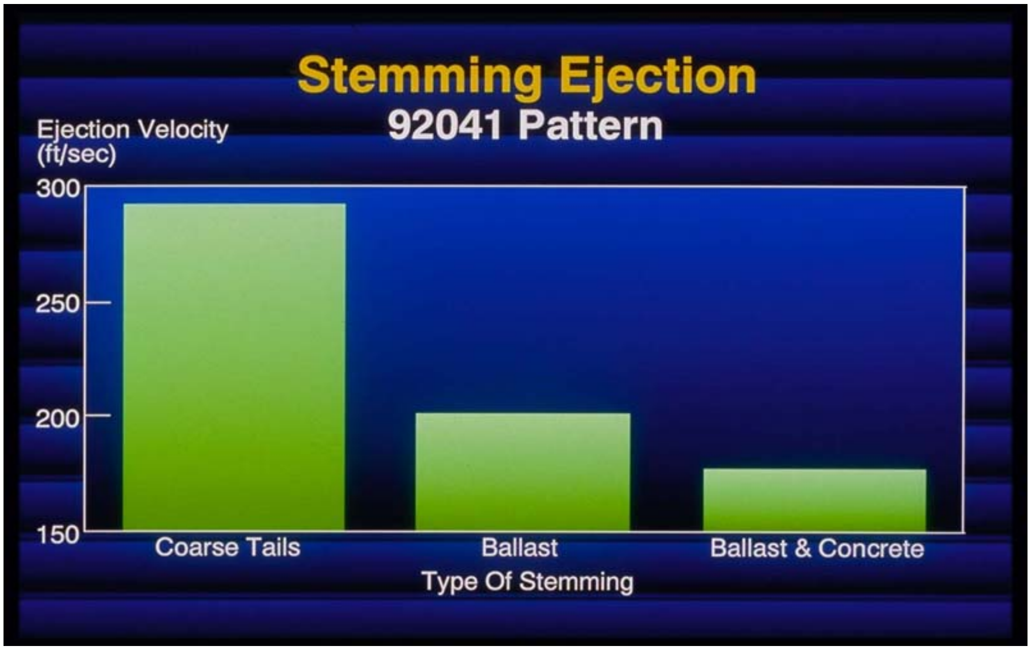


Figure 10. Ejection velocities

DOWNSTREAM PARAMETERS

By surveying the location of production shovels, blasted material is tracked through the primary crusher.(Eloranta,1993) Records of shovel loading speed, crusher throughput and crusher amps can be assigned to stemming test zones. The results for stemming tests in blast 92041 are summarized in the figure 11.

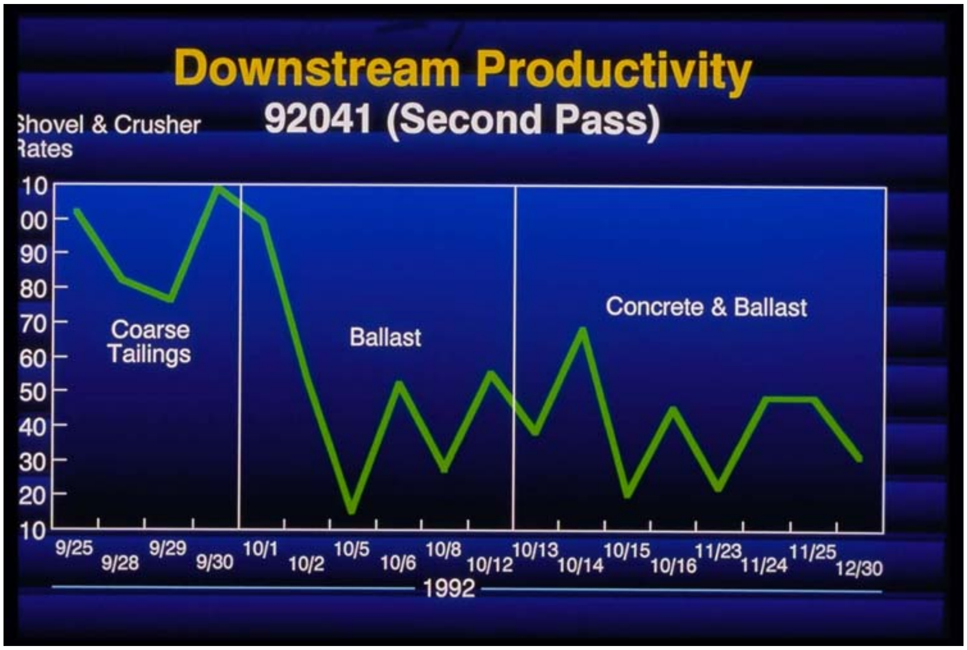


Figure 11. Shovel/Crusher performance

The vertical scale is an arbitrary weighting of the downstream parameters where larger values indicate higher tons per hour and lower electricity usage. Normal stemming of coarse tailings seems to result in better performance than the very coarse ballast with or without poured concrete plugs.

Digital Image Analysis

Blast 92041 contained a test zone in which normal stemming was replaced with a very coarse product referred to as railroad ballast. As the shot was mucked out and hauled to the primary crusher, size fractions were estimated using a digital image analysis method developed by the Bureau of Mines.(Grannes,1986) The following distribution curves (see figure12) summarize the results. The increase in fragment size shown by the lower curve agreed with visual inspection of the muckpile which appeared blocky in the collar area.

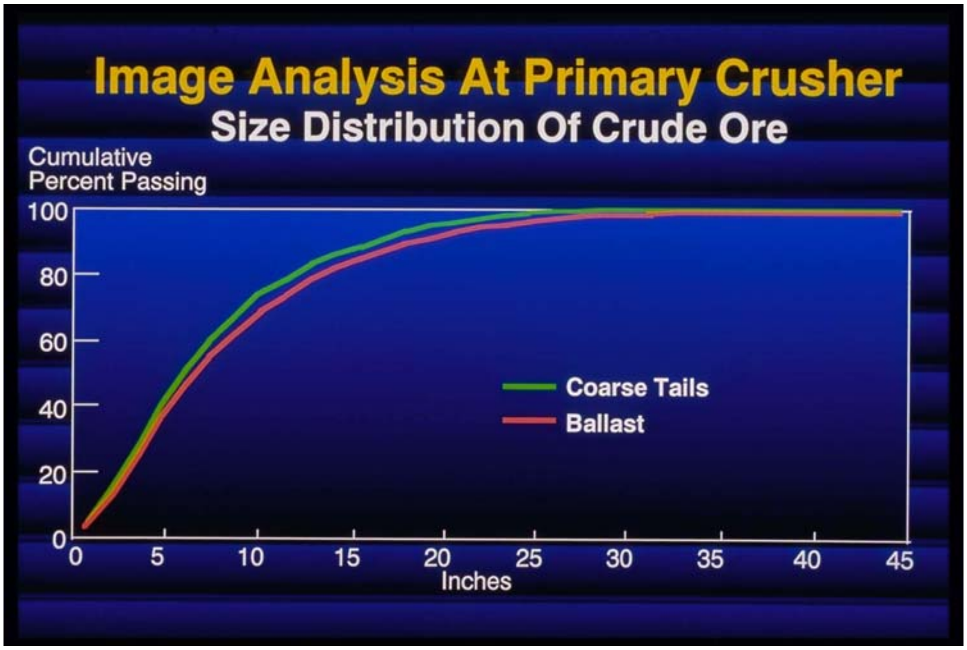


Figure 12. Fragment size distribution

Discussion

The overall effect of stemming enhancements is that it is indeed possible to adjust the confining action of stemming. It is also possible to measure the changes in blast performance. The paradox is the poor blast performance that goes hand in hand with reduced stemming ejection velocity. Shovel performance, crusher performance and size analysis from digital image analysis agreed on this point. One might have expected better performance as energy losses were reduced. One possible cause could be reduction in pressure in the collar zone (see figure 13)

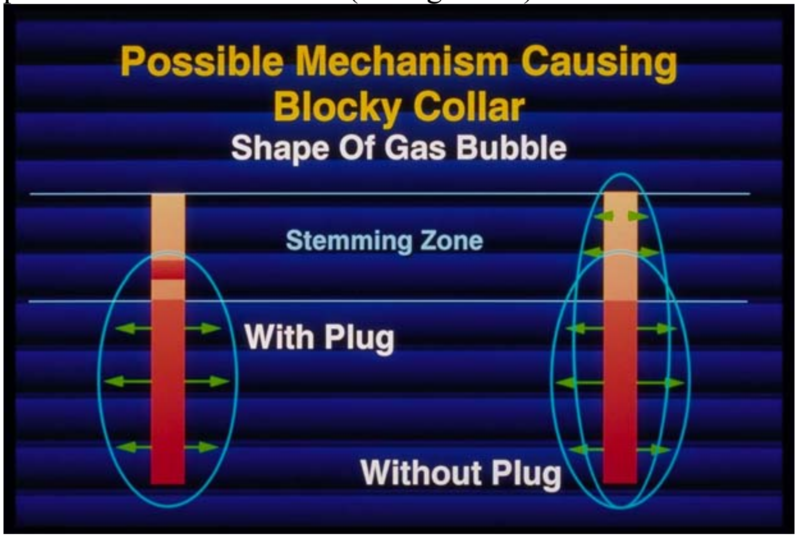


Figure 13. Gas bubble schematic

If stemming enhancement limits the upward propagation of the gas bubble, energy will be expended in the lower borehole zone. By the time stemming begins to move up, the pressure may be too low to do further work in the collar zone. The laminated iron formation, where the tests were done, might also favor this mechanism.

Conclusions

The salient point is that stemming height and stemming size have an important influence on fragmentation. The following items sand out.

1. Vodr cable in the collar does not register ejection time; rather the cable reacts to compression at 5 to 7 milliseconds after detonation.
2. De-coupling of the stemming and powder columns with a reduction in stemming by 2 feet results in higher ejection velocities.
3. Ejection velocities were lower using the coarser minus 3/4 inch and the minus 2-3/4 inch size stemming.

4. Poured and pre-cast concrete plugs in conjunction with coarse stemming reduced ejection velocities about 40%.
5. Digital image analysis agreed with shovel and crusher productivity in showing poorer fragmentation where stemming enhancements were tested.
6. The author has offered a model suggesting that more of the gas energy is expended in the lower portion of the borehole area.

Future work

The next tests will involve a reduction in stemming height in conjunction with various stemming enhancements. The opportunity exists to improve vertical powder distribution and to utilize more of the borehole for the placement of powder. This in turn offers the possibility of expanded drill spacings or decreased powder factors.

Acknowledgements

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