EXPLOSIVES AND BLASTING (OPENCAST)

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INTRODUCTION TO EXPLOSIVES AND ACESSORIES

Definition of Explosives : Explosives is a chemical compound or mixture, when exploded by action of heat, impact, gives large volume of gases in a very short time at high temperature & pressure.

Classification : All commercial Explosives are broadly divided in two categories.

1) Low Explosives
2) High Explosives

Low Explosives : The chemical reaction in low Explosives is called deflagration which is a rapid process of combustion without accompanying any shock wave but gives a heaving effect.

Example : Gum Powder

Chemical Composition :Sodium Nitrate - 72%
Sulpher - 12%
Coal - 16%

High Explosives : Reaction in High Explosives is characterised by an associated shock wave initiated by a detonator. It basically contains.

Oxidisers - Such as Ammonium Nitrate
Fuel Oil
Sensitizers : Methyle Amino Nitrate, Per chlorate Salt
Physical Sensitizer : Entrapped Air Bubbles

Explosive Characteristics :

Various important Explosives
Characteristics are

- Velocity of Detonation (VOD)
- Weight Strength
- Fume Characteristics
- Thermal Stability
- Sensitivity
- Density
- Water Resistance

Velocity of Detonation : It is the speed at which detonation wave travels through the media, it depends upon Explosive type. VOD is measured by, some electronic means or by Dautriche test. Average VOD varies form 2500 M/S - 5800 M/Sec.

Weight Strength : Weight strength is the energy generated by an Explosive relative to that produced by an equal weight of 94 AN 6 FO.

Bulk Strength : It is the energy released per unit volume of Explosive as compared to ANFO. Bulk strength can be calculated from weight strength using the equation

$$\text{Relative Bulk Strength} = \frac{\text{Relative Wt. Strength x Density}}{\text{Density of ANFO}}$$

Water Resistance : Explosives differ widely in resistance to water and moisture penetration. Some Explosives deteriorate rapidly under wet conditions, but others are designed to withstand water for long periods. When blasting is to be done under wet conditions, a water resistant Explosive is preferable.

Sensitivity : An Explosives is required to be insensitive to normal handling, shock and friction, but must remain sufficiently sensitive to be satisfactorily detonated, and capable of propagating satisfactorily, cartridge to cartridge, even over gaps such as may occur in practice.

Density : The density is important when selecting an Explosive for a particular use. With a high density Explosive the energy of the shot is concentrated a desirable feature in tunneling and mining operations in hard ground. On the other hand when the output of lump coal from a mine is important, it is advisable to use a low density Explosive, which distributes the energy along the shothole.

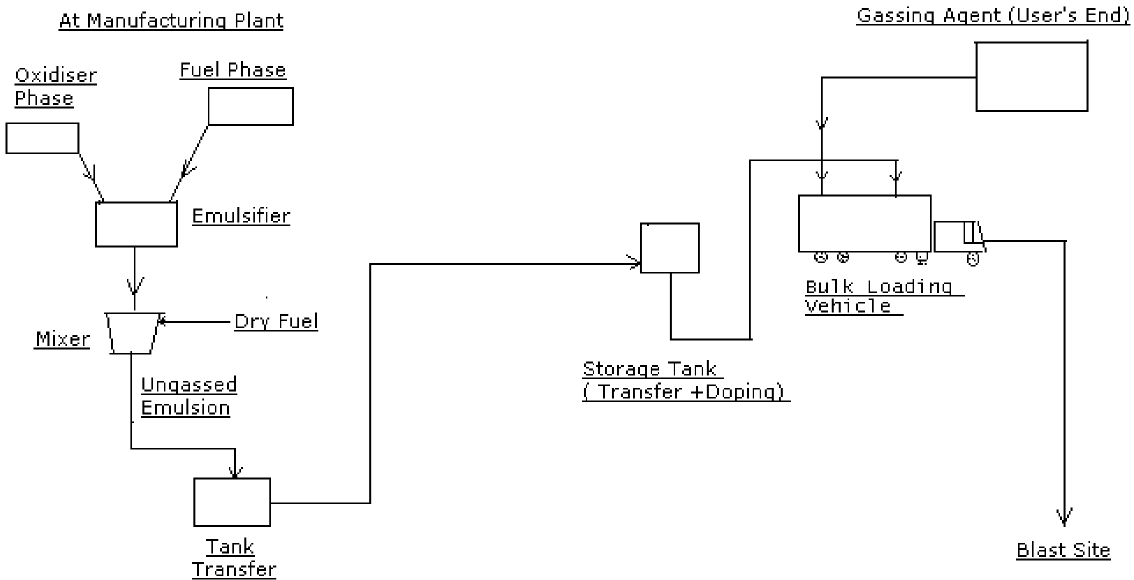
Thermal Stability : Explosives compositions should be such as to be stable under all normal conditions of usage. [The DGMS stipulates that no blast hole shall be charges if the temperature in the borehole exceeds 80^{o}C when blasting in hot ground. Sometimes Explosives have to be used in sub zero conditions in which some explosives become insensitive. Explosives compositions of M/s. Solar Explosives Ltd. are designed to be stable and safe, under all conditions of use. When blasting in hot ground, precautions as stipulated by the DGMS should be adhered to.]

Properties of NG & AN :
Nitro Glycerine (NG) - it is a liquid, insoluble in water, highly sensitive to shock, friction and heat. In all Explosives of N.G. based oniroglycol is mixed for lowering the freezing point, used for hardest rocks and metals and for shooting oil wells.

Ammonium Nitrate (AN) :
It is a weak Explosives base. Difficult to initiate, so a sensitizer like NG or TNT is used. It is Oxygen positive, Hygroscopic, soluble in water. Tendency to form hard cakes.

BULK EMULSION :
Solar Explosives Ltd. has geared up for supply of Bulk delivered system through its subsidiary company Solar Capitals Ltd. This Emulsion technology has been developed indigenously, fine-tuned to the need of mining industry and engineered plants, which can manufacture refined & reliable product. In general Emulsion technology comes in the following categories :
- Re-pumpable Emulsion
- Site Mix Emulsion with support Plant
- Augered Heavy ANFO
- Pumped Doped Emulsion

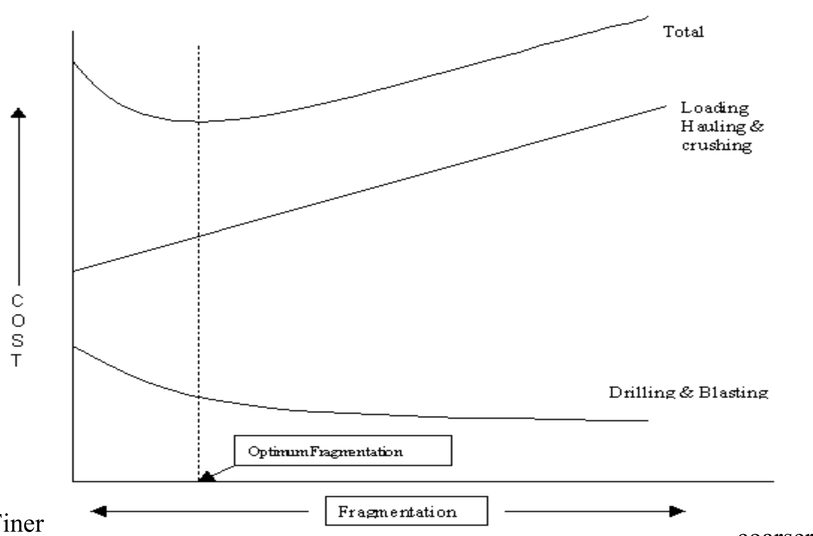
TECHNOLOGY DETAILS :
The Site mixed Bulk Emulsion is emulsion product. To deliver the product bulk loading BMD vehicles are designed to capable of pumping Bulk Emulsion after mixing with density control gassing agent on site. For charging into bore holes a pump is fitted in the delivery system and gassing agent is injected just before the delivery hose. The gassing reaction is completed in about 15 to 20 minutes and accordingly the mixture become sensitive and attains Explosive properties only after the same is delivered into the blast holes.



FLOW SHEET FOR BULK LOADING DOPED EMULSION EXPLOSIVES

OPTIMUM BLAST DESIGN : TECHNO ECONOMIC CONSIDERATIONS

The measure of effectiveness of drilling and blasting operations is not in terms of blasting cost alone, but rather by its contribution of the efficiency and economy of total excavation system. Savings accrued through excessive reduction in the cost of drilling and blasting may well be lost by increased loading., handling and crushing costs. An optimum blast, with improved fragmentation, accounts for increased cost of drilling and blasting, while the cost of loading, handling and crushing are lowered.



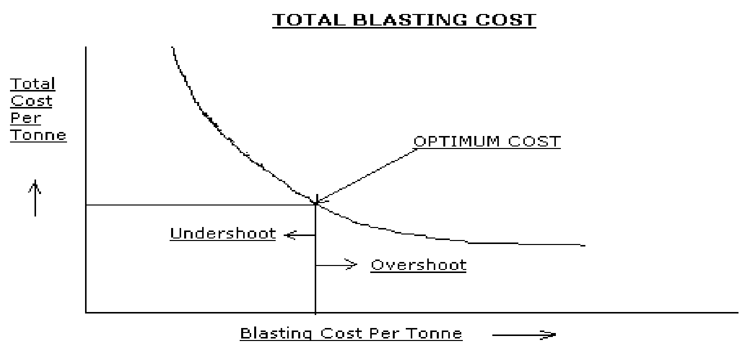
EFFECT OF FRAGMENTATION ON COSTS

CONCEPT OF OPTIMAM BLASTING

The concept developed by Mackenzie describes the total blasting cost as:

$$Ct = \frac{Cd+Cb+Cl+Cc+Ch}{P}$$

Where
Ct = Total blasting cost per tonne of finished product.
Cd = Cost of drilling
Cb = Cost of blasting
Cl = Cost of loading
Ch = Cost of Hauling
Cc = Cost of Crushing
P = Total tones of production



Above Fig. is representation of what Mackenzie believed was the relationship between blasting cost and drilling cost Beginning from to the point to the left of OPTIMUM, he found that it was possible to reduce TOTAL cost by increasing BLASTING COST. He found that better fragmentation produced increased shovel loading efficiency, reduced maintenance repair cost for shovels and dumpers and increased crusher output. Mackenzie achieved a superior "degree of fragmentation" primarily by using more energetic of high strength Explosives. He found higher BLASTING COST produced a very significant reduction in TOTAL COST.

IMPORTANCE OF DEGREE OF PERFORMANCE

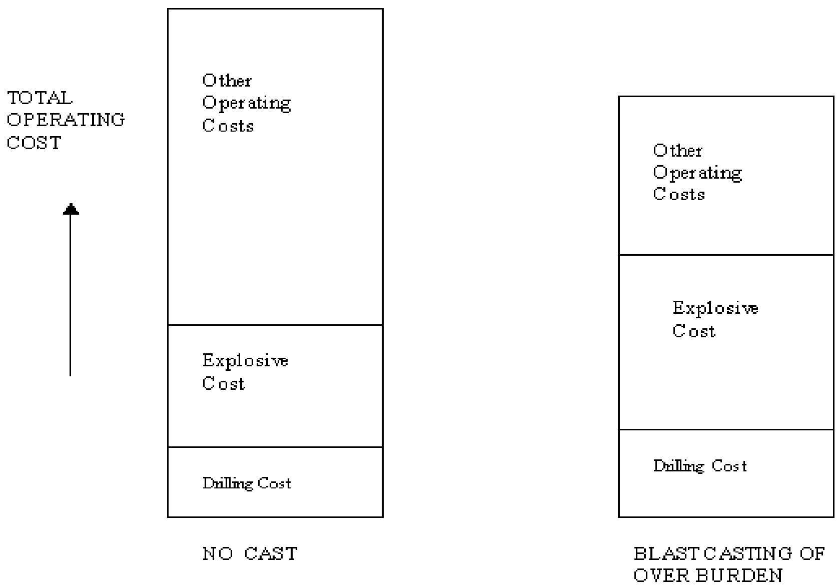
Fragmentation levels required depend on the type of the excavating and hauling equipment. Fragmentation coarser than optimum results in decrease in the loading efficiency and increase in the downtime of loading equipment with added cost of maintenance.

On the other hand, to achieve fragmentation finer than optimum, cost of drilling and blasting may rise disproportionately, which may not be offset by the additional advantage in loading. The blast design should, therefore, be aimed at optimum fragmentation to economise the overall cost of mining.

Once the optimum fragmentation requirements for a particular mining equipment is decided, the question arises as to determine which would need secondary breaking. As has already been mentioned above, any attempt to produce "Zero Boulder Blast" would severely affect the drilling and blasting cost. The optimum ratio of percentage of oversize boulders against the volume of rock of 1-2%.

Blast Economics :

Efficient explosives application is the least expensive method of fragmenting and casting rock. "Blast Casting the Over Burden off Coal" dramatize the economic advantages of using explosive energy to increase production rate and enlarge over all operating profit margins. Fig below graphically illustrate the economic advantages of changing the blast design to an over burden casting configuration. In this case, the burden and spacing dimensions were reducing, which caused the drilling costs to rise marginally. In addition, higher energy explosives were added to increase the energy factor, which is required for higher fragmentation and higher through achieved in case of over burden casting. Despite the increase in drilling and explosives cost. a major reduction in total operating cost was observed due to increase in production and sooner access to the coal. Moreover, reduction in operating maintenance cost due to less running of stripping and hauling equipment because of less material to handle.



RELATIVE COST COMPARISON OF OPERATING COST OF OVERBURDEN TO COAL WITH AND WITHOUT BLAST CASTING

Blast Hole Diameter :

The optimum blast hole diameter is governed by factors such as type of Explosives, Rock mass properties, degree of fragmentation desired and height of bench. An optimum blast hole diameter is that which accommodates that much quantity of Explosives charge which not only breaks away several fold great rock mass but also displaces ti to convenient distance for efficient handling by shovel.

However, in recent years, there is a discernible trend towards larger diameter because of lower drilling cost, and more dependable yield of energy, which assures good fragmentation. But at the same time, if diameter is too large the corresponding large blast hole array may result in poor fragmentation, especially in the case of highly fissured of jointed strata. As per thumb rule Dia of hole = Bench Height / 90 to 120

SELECTION OF OPTIMUM BURDEN & SPACING

The most critical among geometric parameters of blasting is the burden, which has the greatest influence on fragmentation. For any particular geological setting, there is an optimum burden for which the volume of well-fragmented and loosened rock is maximum.

If burden is too large, shock wave remains incapable of extending radial cracking upto the free face and heave energy is unable to provide adequate displacement. Gasses are bottled up within the blast holes for period of time, which results in rapid decay of effective borehde pressure.

On the other hand, if the burden is too low, fracturing by shock increases and breakage by heave energy decreases and much of heave energy is lost as air blast.

Thus, the optimum fragmentation burden is that which allows the gasses to losses virtually all of their energies by the time they escape into the atmosphere without producing any air blast, with minimum objectionable side effects, like toe, air blast, ground vibrations etc.

As per Thumb rule (1) B = 20 to 30 times dia of hole, or
(2) B = 1/3 Bench Height

Spacing

Spacing must be large enough to prevent excessive overlap and over break zones behind adjacent holes but just small enough to give a relatively even distribution of Explosives energy in the rock to be broken.

An interesting conclusion of the study conducted by the Department of Mining Engineering, Banaras Hindu University was that, at Burdens smaller than optimum fragmentation burden, the fragmentation was finer even at S/B value of 5.0 compared to the results obtained at optimum and greater than optimum fragmentation burden with smaller S/B values of even 1.0.

For Lime Stone : S = 0.9 B + 0.91 and for Coal Measure Strata : S = 1 to 1.5 B

Sub - Drilling

Effective sub drilling of about 8.d or 0.3 x B has been found to be satisfactory. In dipping faces, sub drilling of 10.d to 12.d may be necessary in front row because of the excessive toe burden. Sub drilling beyond 12.d rarely succeeds in pulling heavy toe. Instead it tends to make the situation worse.

Stemming

The gaseous energy of an Explosives column will be utilised only if stemming is proper. It should be around 0.7 x Burden.

Depth of Hole

It mainly depends upon the size of machinery, but for better blast results depth D = 2.1 to 2.25 B (B is Burden)

Delay Initiation Sequences

In multi row blasting, various delay initiation sequences are possible. They are :

1. Instantaneous
2. Row Delay
3. V, V1, V2 pattern

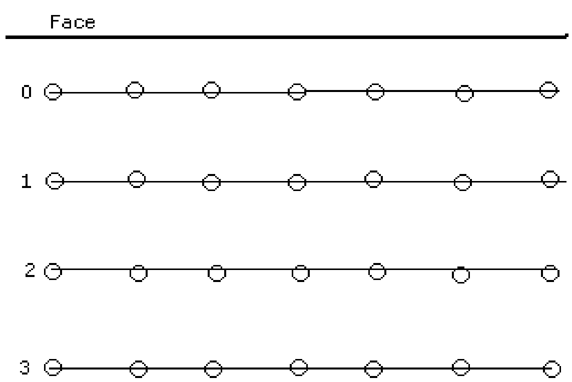
Delay Initiators commonly used are :

a) Electric delay detonators (ms) in conjunction with detonating cord down lines and/or Trunk lines. Delay detonators are tied to down lines of individual holes or to trunk line.
b) Cord Relays (Detonating Relays) in conjunction with detonating cord trunklines and down lines.
c) Down-the-hole non-electric delay initation system such as NONEL with or without additional surface delays.
d) Use of electric delay detonators in conjunction with sequential blasting machine.
e) Combination of (c) and (d) above.

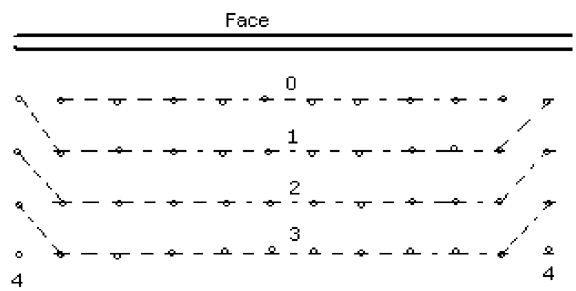
The success of blasts using electric delay detonators largely depends on its accuracy, quality and satisfactory functioning of these detonators. Only II delay periods (0-10) are available in short delay detonators (ms) which greatly restricts the blast size, especially if one plans to use v or v_i patterns or is required to provide a delay interval higher than their nominal values, thus warranting a need to skip one or two delay numbers.

In cord relays, the blasting engineer has a very simple and versatile tool, which helps him carry out big blasts using large number of rows and yet ensuring adequate delay interval provided for. The probability of a misfire in a blast using cord relays is rather remote, because, while blasting, with detonating relays, additional surface detonation paths are always provided for the blast holes thus ensuring trouble free blasts. The pros and cons of the various initiation sequences mentioned earlier are discussed below.

1. **Instantaneous Blasts :** In multirow blast where no delays in the surface hookup. All boreholes detonate more or less simultaneously. Except the first row, the back rows cannot effectively breakout and move in a forwardly direction. They crater up towards the only free face available, viz. bench surface. Such blasts results in poor fragmentation, tight muck piles, excessive fly rock and ground vibration/air blast. This method is not recommended.
2. **Row Delay :** In this method, individual rows in a blast are delayed in a sequence, (figure) so that the front row fires first and then the back rows in a sequence, thus creating free face for the individual rows. Though lot of forward movement of broken rock is achieved in this method. The muck pile is generally very loose and scattered. Simultaneous detonation of all holes in a row, results in high charge weights per delay resulting in excessive ground vibrations and often back break is considerable because of simultaneous detonation of all charges in the back row. This result in uneven walls and slope stability problems, modified row delay is shown in figure, which reduces, side-tear. Staggered hole patterns give marginally better fragmentation as compared to in-line patterns figure.



Row Delay (In-Line)
(Square Pattern)



Modified Square In-Line Pattern

V, V_1, V_2 Patterns : These Pattern are far superior, to row delays. These result in superior fragmentation due to reduce hole burdens and increased spacing at the time of hole initiation and also due to inflight collision of broken rock during its movement. The delayed action of holes in the back row reduces over break ensuring increased wall stability.

The best available pattern is one where the holes are drilled (staggered) on a equilateral triangle pattern. This in a drilled spacing to burden ratio of approximately 1.16. It has been observed that an effective spacing (Se) to Burden (Be), ratio of about 3.5 is achieved with holes drilled on an equilateral triangle grid and fired using a V_1 initiation sequence.

Drilling (staggered) equilateral triangular pattern require more operator skill and supervision as compared to in-line patterns. Clear marking of the hole positions in advance by a responsible person would help the drillers immensely. Fig. gives various delay patterns discussed above.

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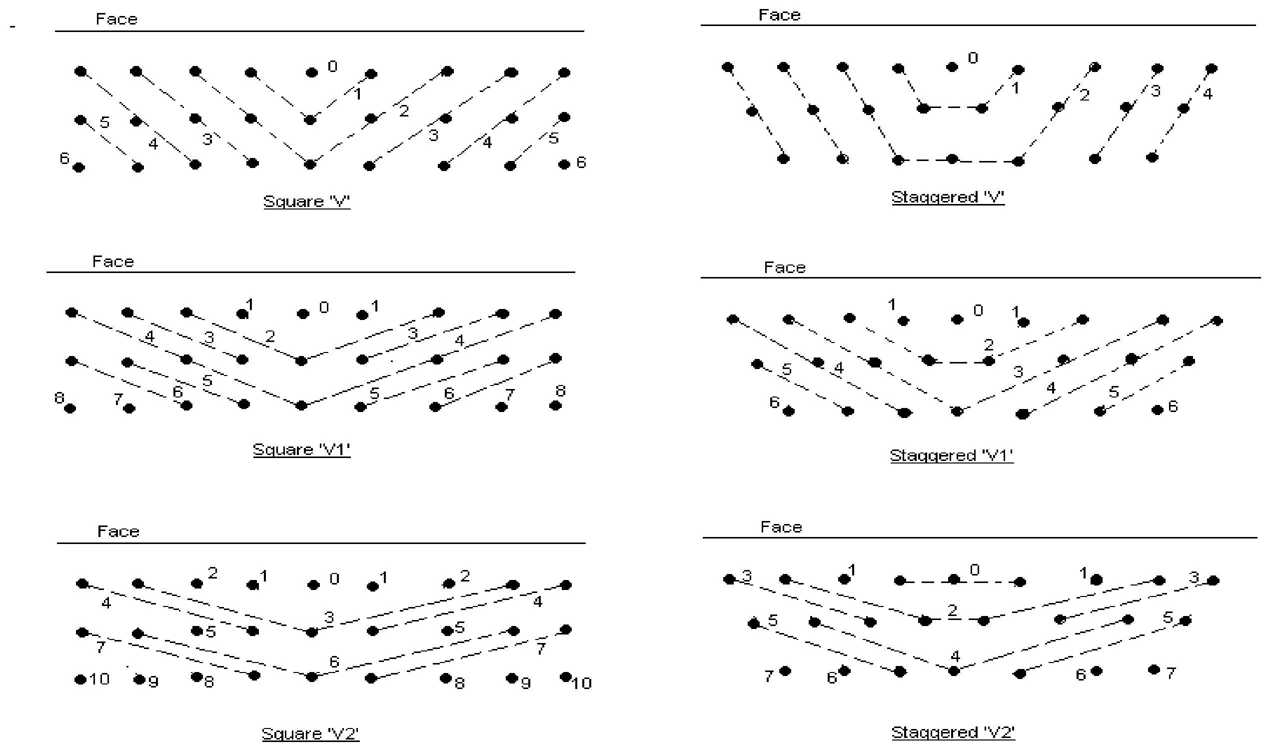


Blastholes / Initiation patterns for shot fired to an open face

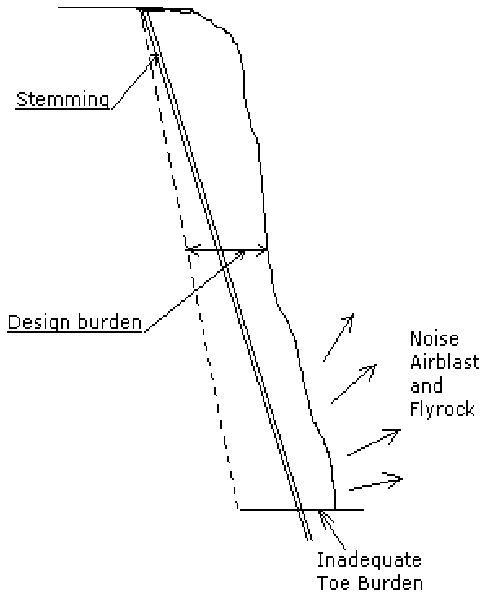
FLYROCK PROBLEMS IN OPENPIT BLASTING

Flyrock in open pit blasting usually means the unexpected/undesired outward projection of rock mass from blasting. Flyrock should be differentiated from 'throw' which now a days can be fairly controlled to produce a desired shape of the muck-pile for efficient loading. The Flyrock generated as such often poses a serious problem to the users of Explosives, as not only the mine equipment are at risk, but also the personal safety and adjacent property are endangered.

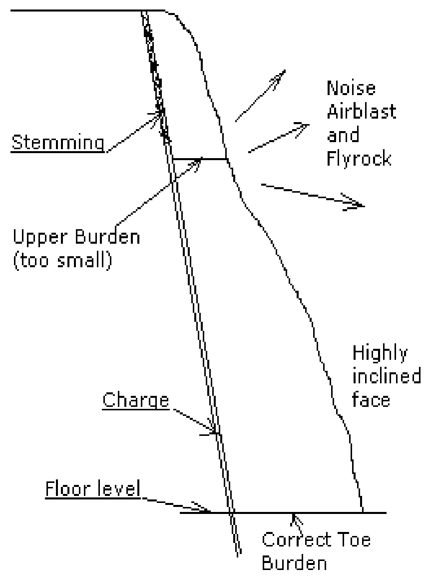
Cause / Formation of Flyrock

Many factors could contribute to the occurrence of undesired fly rock, like :

i) Front Row Burden : Flyrock can be ejected from front row blast holes where insufficient burden exists either at the collar or at the toe. Reduced collar burden often occurs with vertical drilling in an inclined face to take care of the desired toe burden; on the other hand sufficient toe burden; could occur where the face has been under-cut or where excessive blast-hole deviation has occurred in angle drilling (see figure)



Noise, airblast and flyrock caused by an inadequate toe burden



Noise, airblast and flyrock caused by an upper burden which is too small

ii) Stemming Depth/Stemming Material : The collar region is usually fractured before hand due to back-break from previous blast or due to sub-grade blasting from the bench above. As the stemming depth decreases, a larger proportion of explosion gases become available for premature ejection of this pre-fractured rock. The stemming material acts to confine the explosion gases to perform the useful work before venting. With inefficient stemming material the gases stream-up the blast-hole prematurely resulting in fly rock formation.

iii) Initiation Sequence : Progressive relief of burden in forward direction through use of inter-row delays is essential for optimum fragmentation and muck-pile looseness. However if the inter-row delay intervals are not adequately designed then the rear rows of holes may crater upward in absence of forward displacement; this will create substantial fly rock. Similar phenomena can happen when blast-holes are initiated out of sequence (back row initiated before front row).

iv) Blast Pattern/Blast Shape : When Explosives charge column is overburdened, vertical crate ring can take place causing fly rock. Also when the borehole depth to burden ratio is around unity, forward displacement is inhibited due to higher stiffness length may have to be reduced to accommodate the necessary quantity of charge in the hole, leading to the fly rock from the collar region.

If the shape of the blasting round is such that length to width ratio for the bench is less than 1.5, the rock on both sides of the blast area has a constraining of drag effect on forward displacement thus resulting in fly rock from rear rows.

v) Major Geological Faults : Where Explosives charges intersect or are in close proximity to the major geological faults or planes of weakness, the high pressure explosion gases preferentially stream out along these weakness plans. The concentrations of gas pressure energy in these areas lead to fly rock formation.

Control of Flyrock

It should be possible to control the fly rock formation to acceptable levels with an appropriate blast design followed by adequate supervision during charging. the major parameters associated with controlling fly rock include.

i) Blast-Hole Location/Charge Configuration :
To avoid the irregularities on the front row burden it is important to ensure that the holes are correctly collared with respect to the back-break/inclination of the face and also that digging alongside the initiation face well controlled.

Regarding the charge configurations it is often misunderstood to assume that under charging the front row holes solves all problems associated with fly rock. Inadequate forward displacement of the front row burden arising out of the under charging of these holes result in fly rock from vertical catering of the rear holes. It is therefore important that the charging of the front holes should be critically determine with some tolerance for forward throw to avoid harmful fly rock from the back. When the blast hold diameter is increased say from 100 mm to 200 mm, the linear packing density of fully coupled Explosives increases by the square of the ratio of the diameters. In such cases change in the explosives charge distribution particularly in the collar portion is a must to take care of the increased available gas volume with increased packing density. Where permanent the bedding planes are encountered, deck charging should be used to reduce the concentration of charge located directly adjacent to these planes of weakness.

ii) Stemming Medium : Where fly rock posses a serious problem, the stemming length should not be less than the hole burden. Also an effective stemming material like crushed angular rock should be used to prevent premature venting of explosion gases through the stemming column. the fine drill cuttings commonly used in most of the opencast operations have been found to be a poor stemming medium as far as the fly rock control is concerned.

iii) Initiation Pattern/Sequence : The forward fly rock could be fairly controlled to the commonly used 'inline open loop' pattern. The maximum inter-row delay interval consistent with the absence of cut off helped in minimising the fly rock formation. As a thumb rule an inter-row delay of 4-8ms/m of burden could be used for this purpose. Adequate care should be taken while connecting the delay devices in the holes/rows and the initiation sequence properly checked before firing to avoid initiation pf blast holes out of sequence.

iv) Blast Pattern/Shape : Experience has shown that blasts designed on a face length to width ratio in the range of 3 to 4 produces minimum fly rock. In most of our opencast mines as the face length available is limited; it may be useful to restrict to a maximum of 4 rows for large diameter holes.

v) Protection Cover : Protective covering of blast with blasting mats, scrap conveyor belting of truck tyres etc. can be used when there is a serious need to drastically reduce or even eliminate the incidence of fly rock. However as this poses a constraint on the overall rock movement, chances of fly rock due to cratering of rear charges could be there if the blast is not properly designed.
Fly rock also result from secondary blasting by pop shooting. This can happen if the charge is too heavy of if the blast hole is incorrectly positioned in the burden. The blast hole should be directed as locate the charge in the centre of the boulder. The correct powder factor should also be determined and adhered to in routine secondary blasting.
Using the guidelines given above, it is hoped that the quarry managers should be able to control the fly rock to acceptable levels from both primary and secondary blasting thereby avoiding expensive losses.

GROUND VIBRATION DUE TO BLASTING :
Optimum Blasting for Indian Geomining Conditions, Suggestive Standards & Guidelines :

Ground vibrations is considered as one of the most undesirable side effects of rock residential buildings in the vicinity of mining operations and thus may lead to conformation and hamper normal production of the mine. Presently huge amount of explosive usage in mining sectors coupled with urban sprawls encroaching the area of mining operation, has called for much better control of blast produced ground vibrations due to greater public environmental consciousness. Broadly, ground vibrations may be controlled by using the following safety measures.

(a) Use Delay Detonators
(b) Optimization of the firing time by trials
(c) Proper Blast Design
(d) Lower Charge Per Delay
(e) Direction of Initiation

USBM PREDICTOR EQUATION :
This equation considers cylindrical Explosives geometry for long cylindrical charges in which any linear dimension should be scaled with square root of the charge weight. the equation is of the form :
USBM : $V = K\,(D/Q^{1/2})^{-B}$
Where, V is the peak particle velocity, D is the distance of the measuring transducer and Q is the maximum charge weight per delay. K and B are site constants to be determined by regression analysis.

Known methods and techniques to reduce Ground Vibrations :
The following methods and Techniques have been successful in reducing ground vibration and resulting annoyance complaints :

1. Reduce weight of Explosives per delay. this is perhaps the greatest factor affecting the amplitude of particle velocity. Any decrease in amount of explosives through smaller hole diameter, reduced bench height and or decking will reduce the probability of damage.
2. Reduce explosives confinement by :
   a. Reducing burden and spacing.
   b. Reducing buffers in front of face holes.
   c. Reducing stemming, but not to the degree enhancing Air Blast and/or Rock Fly.
   d. Reducing sub-drilling.
   e. Reducing Hole depth.
   f. Using a blast design that produces maximum relief: this means using large delays between holes or rows of holes. Optimum delay intervals can be determined and substantiated with the use of high-speed motion picture photography.
   g. Allowing at least one free face to blast.
3. Whenever possible, the progression of detonating holes or a row of holes through millisecond delay intervals should progress away from the structure.
4. Use larger delays, where geological conditions in conjunction with initiation system permit.
5. Where possible, keep the total lapsed time of the entire blast below 1-second duration.
6. Use electric millisecond detonators with sequential blasting machines or an initiating system with an adequate number of delay intervals preferably, with down the hole delays causing bottom charge and deck charge blast separated by delays.
7. It has been observe that, using pre-splitting the production blast and by using air decking the ground vibration is reduced considerably.

THRESHOLD VALUE: (Ground Vibration)
DGMS (India) vide the Circular No. 7 Dt. 29.8.97 have specified permissible standards of peak particle velocity (in millimeter per second) depending on type of structure and dominant excitatory frequency. Permissible peak particle velocity at the foundation level of structure in mining areas is:

Type of Structure	PPV in mm/sec at a foundation level of Structure at a frequency.		
	<8Hz	**8-25 Hz**	**>25Hz**
Building structure not belonging to owner			
1.Demostic House structure kucha brick &cement	5	10	15
2. Industrial building RCC& Framed Structure	10	25	25
3.Objects of historical importance and sensitive structure	2	5	10
Building belonging to owners with limited span to life			
1.Domastic houses structure Kucha bricks & cement	10	15	25
2.Industrial Building RCC & framed structure	15	25	50

BLASTING BY NON-ELECTRIC INITIATION SYSTEM:

Conventional DF initiation system uses 10grms of PETN (High Explosives) per meter of DF. This causes violent detonation, noise etc which disrupt its surroundings and causes heavy nuisance. Moreover, with conventional DF blasting the full utilisation of explosives column can not be achieved. Thus, toe formation; poor fragmentation, undesired throw etc take place.

To overcome the bad effects of DF system of blasting, Shock Tube Non-Electric System have been developed. The main component of Non-Electric Initiation System is shock tube, a hollow tube made by advance material design to withstand high abrasion. Thin coating of the reactive mixture (PETN and Aluminum) are made inside the shock tube, propagate the initiation signal all along the tube, over coming through knots and kinks to reach other end where delay detonator of desired delay timings are attached.

Advantage and Applicability of Non-Electric Initiation System :

1. Environment friendly

a) Non-Electric Initiation System (NONEL) produces much less noise, as compared to conventional system of blasting i.e. DF blasting.

b) The ground vibration due to blasting is reduced greatly as different delays can be used for Deck Charges, there by reducing quantity of explosive per delay.

c) By using Non-Electric Initiation System the occurrence of fly- rocks are reduced greatly.

This enables to carryout blasting operations near habitation and other environmentally sensitive areas like, near to villages, adjacent u/g mines, High Tension Electric transmission lines etc.

2. Economically viable

a) True bottom initiation can be effected by using Non-Electric Initiation System. It does not desensitises the explosive column charge and does not disturb stemming column (Due to low core charge in the shock tube as compare to DF).

b) By use of NONEL and by blast pattern expansion in open cast mines powder factor can be increased by 10 to 12% and total Drilling & Blasting cost can be reduced.

3. Efficiency in use

Non-Electric Initiation System provides true bottom hole initiation; therefore maximum energy transfer from explosive to rock takes place, which provides effective toe removal, improve fragmentation, better utilization of explosive energy and increased energy yield per unit cost.

4. Enhanced safety

a) Non-Electric Initiation System is truly non electric in nature; this immune to initiation by all kinds of static and stray electricity.

b) NONEL shock tube is insensitive to flame, friction, impact occurred during normal conditions of usage.

c) With this system chances of misfire due to cutting–off the surface and down lines is nil; as the surface initiation travels much in advance to the actual blasting (breaking of rock).

5. User Friendly

Use of Non-Electric Initiation System does not require the knowledge of electric circuit as in the case of electric detonators. Connection is fast, simple and flexible as compared to conventional system of blasting.

"DOs AND DON'Ts"

Definitions

1. The term "Explosives" as used herein includes any or all of the following: dynamite, black blasting powder, pellet powder, blasting caps, electric blasting caps and detonating fuse.
2. The term "Electric Blasting Cap" as used herein includes both instantaneous electric blasting caps and all types of delay electric blasting caps.
3. The term "Primer" as used herein means a cartridge of explosives in combination with a blasting cap or an electric blasting cap.

A. When Transporting Explosives

1. DO obey all laws and regulations.
2. DO see that any vehicle used to transport explosives is approved by CCE and in proper working condition and equipped with a tight wooden or non-sparking metal floor with sides and ends high enough to prevent the Explosives from falling off. Wiring should be fully insulated so as to prevent short-circuiting, and at least two fire extinguishers should

be carried. The vehicle should be plainly marked so as to give adequate warning to the public of the nature of the cargo.

3. DON'T permit metal, except approved metal truck bodies, to contact cases of explosives. Metal, flammable, or corrosive substances should not be transported with explosives.
4. DON'T allow smoking or unauthorized or unnecessary persons in the vehicle.
5. DO load and unload Explosives carefully. Never throw Explosives from the vehicle.
6. DO see that no Explosives, including detonating fuse, are transported along with blasting caps and/or electric blasting caps/detonators.
7. DON'T drive trucks containing explosives through cities, towns or villages, or park them near such places as restaurants, garages and filling stations, unless it cannot be avoided.
8. DO request that explosives deliveries be made at the magazine or in some other location well remote from populated areas.
9. DON'T fight fires after they have come in contact with explosives. Remove all personnel to a safe location and guard the area against intruders.

B. When storing Explosives

10. DO store explosives in accordance with laws and regulations.
11. DO store explosives only in a magazine which is clean, dry, well ventilated, reasonably cool, properly located, substantially constructed, bullet and fire resistance and securely locked.
12. DON'T store blasting caps or electric blasting caps in the same box, container or magazine with other explosives.
13. DON'T store explosives, fuse, or fuse lighters in a wet or damp place, or near place, or near oil, gasoline, cleaning solution or solvents, or near radiators, steam pipes, exhaust pipes, stoves, or other sources of heat.
14. DON'T store any sparking metal, or sparking metal tools in an explosives magazine.
15. DON'T smoke or have matches, or have any source of fire or flame in or near explosives magazine.
16. DON'T allow leaves, grass, brush, or debris to accumulate within 25 feet of an explosives magazine.
17. DON'T shoot into explosives or allow the discharge or firearms in the vicinity of an explosives magazine.
18. DO consult the manufacturer if nitroglycerin from deteriorated explosives has leaked onto the floor of a magazine. The floor should be desensitized by washing thoroughly with an agent approved for that purpose.
19. DO locate explosives magazines in the most isolated places available. They should be separated from each other, and from inhabited buildings, highways, and railroads, by distances not less then those recommended in the Explosives rules.

C. When using Explosives

20. DON'T use sparking metal tools to open kegs or wooden cases of explosives. Metallic slitters may be used for opening fiberboard cases, provided that metallic slitter does not come in contact with the metallic fasteners of the case.
21. DON'T smoke or have matches, or any source of fire or flame, within 100 feet of an area in which explosives are being handed or used.
22. DON'T place explosives where they may be exposed to flame, excessive heat, sparks or impact.
23. DO replace or close the cover of explosives cases or packages after using.
24. DON'T carry explosives in the pockets of your clothing or elsewhere on other person.
25. DON'T insert anything but fuse in the open end of blasting caps.

26. DON'T strike, tamper with or attempt to remove or investigate the contents of blasting caps, or try to pull the wires out of an electric blasting cap.
27. DON'T allow children or unauthorized or unnecessary persons to be present where explosives being handled or used.
28. DON'T handle, use or be near explosives during the approach or progress of any electrical storm. All persons should retire to a place of safety.
29. DON'T use explosives or accessories, equipment that are obviously deteriorated or damaged.
30. DON'T attempt to reclaim or to use fuse, blasting caps, electric blasting caps, or any explosives that have been water soaked, even if they have dried out. Consult the manufacturer.

D. When Preparing The Primer

31. DON'T make up primer in a magazine, or near excessive quantities of explosives, or in excess in immediate needs.
32. DON'T force a blasting caps or an electric blasting caps into dynamite. Insert the cap into a hole made in the dynamite with a punch suitable in the purpose.
33. DO make up primes in accordance with proven and established methods. Make sure that the cap shell is completely encased in the dynamite or booster and so secured that in loading no tension will be placed on the wires or fuse at the point of entry into the cap.

E. When Drilling and Loading

34. DO comply with applicable regulations relative to drilling and loading.
35. DO carefully examine the surface or face before drilling to determine the possible presence of unfired explosives. Never drill into explosives.
36. DO check the borehole carefully with a wooden tamping pole or a measuring tape to determine its condition before loading.
37. DO recognize the possibility of static electrical hazards from pneumatic loading and take adequate precautionary measures. If any doubt exists, consult your explosives supplier.
38. DON'T stack surplus explosives near working areas during loading.
39. DO cut from the spool the line of detonating fuse extending into a borehole before loading the remainder of the charge.
40. DON'T load a borehole with explosives after springing (enlarging the holes with explosives) or upon complication of drilling without making certain that it is cool and that it does not contain any hot metal, burning or smoldering material. Temperature in excess of 150 F is dangerous.
41. DON'T spring a borehole near another hole loaded with explosives.
42. DON'T force explosives into a borehole or through obstruction in a borehole. Any such practice is particularly hazardous in dry holes and when the charge is primed.
43. DON'T slit, drop, deform or abuse the primer. DON'T drop a large size, heavy cartridge directly on the primer.
44. DO avoid placing any unnecessary part of the body aver the borehole during loading.
45. DON'T load any borehole near electric power lines unless the firing line, including the blasting cap wires, is so short it cannot reach the power wires.
46. DON'T connect blasting caps, or electric blasting caps, to detonating fuse except by methods recommended by the manufacturer.

F. When Tamping

47. DON'T tamp dynamite that has been removed from the cartridge.
48. DON'T tamp with metallic devices of any kind, including the metal end of loading the metal end of loading poles. Use wooden tamping tools with no exposed metal non-sparking metal connectors for joint poles. Avoid violent tamping. Never tamp the primer.
49. DO confine the explosives in the borehole with sand, earth, clay or other suitable incombustible stemming material.
50. DON'T kink or injure fuse, or electric blasting cap wires, when tamping.

G. When Shooting Electrically

51. DON'T uncoil the wires or use electric blasting caps during dust storms or near any other source of large charges of static electricity.
52. DON'T uncoil the wires or use electric blasting caps in the vicinity in of radio frequency transmitters, except at safe distances. Consults the manufactures or the institute of makers of explosives pamphlet on "Radio Frequency Hazards."
53. DO keep the firing circuit completely insulated from the ground or other conductors such as bare wires, rails, pipes or other part of stray currents.
54. DON'T have electric wire or cables of any kind near electric blasting caps or other explosives except at the time and for the purpose of firing the blast.
55. DO test all the circuit of blasting caps, either single or either connected in a series circuit, using only a blasting galvanometer specifically designed for the purpose.
56. DON'T use the same circuit either electric blasting caps made by more then one manufacturer, or electric blasting caps of different style or function even if made by the same manufacturer, unless such use is approved by the manufacturer.
57. DON'T attempt to fire a single electric blasting cap or a circuit of electric blasting caps with less then the minimum current specified by the manufacturer.
58. DO be sure that all the wire ends to be connected are bright and clean.
59. DO keep the electric cap wires or leading wires short-circuited until ready to fire.

H. When Shooting With Fuse

60. DO handle fuse carefully to avoid damaging the covering. In cold weather warm slightly before using the avoid cracking the waterproofing.
61. DON'T use the short fuse. Know the burning speed of the fuse and make sure you time to reach the place of safety after lighting. Never use less then two feet.
62. DON'T cut fuse until you are ready to insert it into a blasting cap. Cat of an inch or two to ensure a dry end. Cut fuse squarely across with sharp blade. Seat the fuse lightly against the cap charge and avoid twisting after it in a place.
63. DON'T crimp blasting caps by any means except a cap crimper designed for the purpose. Make certain that the cap is securely crimped to the fuse.
64. DO light fuse with a fuse lighter designed for the purpose. If a match is used the fuse should be slit at the end and the match head held in the slit against the powder core. Then scratch the match head with an abrasive surface to light fuse.
65. DON'T light fuse until sufficient stemming has been placed over the explosive to prevent sparks or flying match heads from coming into correct with the explosive.
66. DON'T hold explosives in the hands when lighting fuse.

I. Underground Work

67. DO use permissible explosives only in the manner specified by the Director General of Mines Safety.

68. DON'T take excessive quantities of explosives into a mine at any one time.
69. DON'T use black blasting powder or pellet powder with permissible explosives or dynamite in the same borehole in a coal mine.

J. Before and After Firing

70. DON'T fire a blast without a positive signal from the one in charge who has made certain that all surplus explosives are in a safe place, all persons and vehicles are at a sage distance or under sufficient cover and that adequate warning has been given.
71. DON'T return to the area of any blast until the smoke and fumes from the blast have been dissipated.
72. DON'T attempt to investigate a misfire too soon. Follow recognized rules and regulations or if no riles of regulations are in effect, wait at least one hour.
73. DON'T drill, bore, or pick out a charge of explosives that has misfired. Misfires should be handled only by or under the direction of a competent and experienced person.

K. Explosives Disposal

74. DON'T abandon any explosives.
75. DO dispose of or destroy explosives in strict accordance with approved methods. Consult the manufacturer or DGMS pamphlet measures on destroying explosives.
76. DON'T leave explosives, empty cartridges, boxes, liners, or other materials used in the packing of explosives lying around where children or unauthorized persons or livestock can get at them.
77. DON'T allow any wood, paper, or any other materials employed in packing explosives to be burned in a stove, a fireplace, or other confined space, or to be used for any purpose. Such materials should be destroyed by burning at an isolated location out of doors and no person should be nearer than 100 feet after the burning has started.

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Author has presented number of technical papers in many of the seminars and journals on varied topics like Overburden side casting by blasting, Blast induced Ground Vibration and its control, Tunnel blasting, Drilling & blasting in metalliferous underground mines, Controlled blasting techniques, Development of Non-primary explosive detonators (NPED), Signature hole blast analysis with Electronic detonator etc.

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