# INTRODUCTION

Blasting is a powerful tool for rock excavation in civil work, quarrying and mines. It produces fast, efficient and less costly way to accomplish rock handling. However, explosives is always kept mysterious for security reasons. It is traditionally delegated to the shotfirer to handle this key work portion. It is noticed now there exists a communication gap in between the management/ controlling parties with the field operating people, because their understanding to blasting concept are deviated. It is considered now being the time the engineers shall focus to understand more what practical blasting is. The starting point shall be learning of the basic and fundamental concept of blasting. From there, they are able to use basic concept to assess their specific site environments, make judgment and design best optimum blasting in a safe and efficient way. I do not see it is a good idea to extract content of individual article and blindly adopt in your site as "blasting guideline". Let's understand the basic.

# Explosives

- Mixture of chemical compounds which rapidly decompose, instantly releasing large quantity of energy in form of heated gas at a high pressure

Basic Ingredients

- oxydiser
- fuel
- sensitizer

# Explosives shall be oxygen balanced

i.e. complete combustion in the chemical reaction to yield the designed performance


Example: ANFO blasting agents

$3\ NH^4\ NO^3 + CH^2 \rightarrow CO^2 + 7H^2O + 3N^2 + \text{heat}$

m.w. 3 (80.1gm) +(14gm) = 254.3gm

NH4NO3 = 94.5%

CH2 = 5.5%

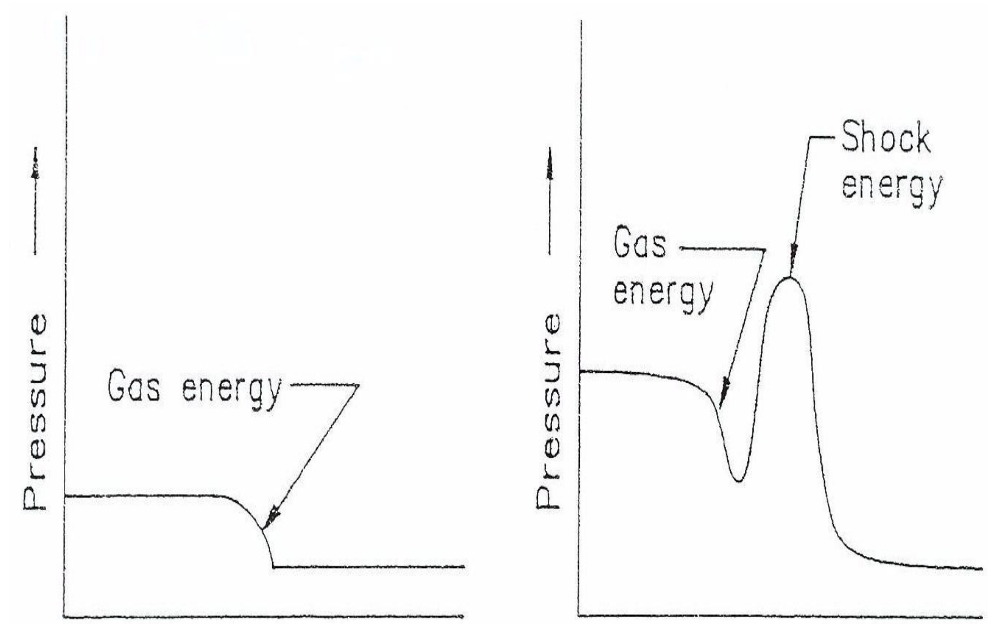
# Type of explosives

- High explosives

  High VOD, detonated with shock wave propagation associated with gas expansion, such as dynamite, water gels, emulsion

- Low explosives

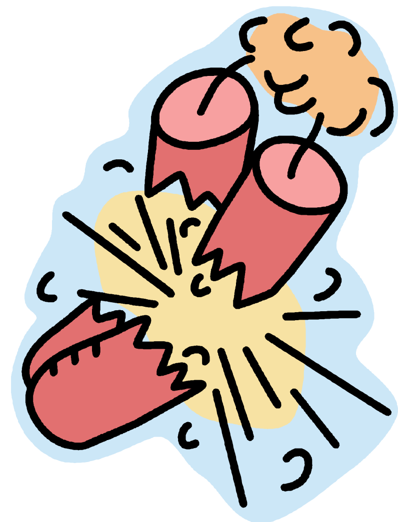
  Low VOD, deflagrated with gas expansion only such as black powder




**Detonation of low and high explosives**

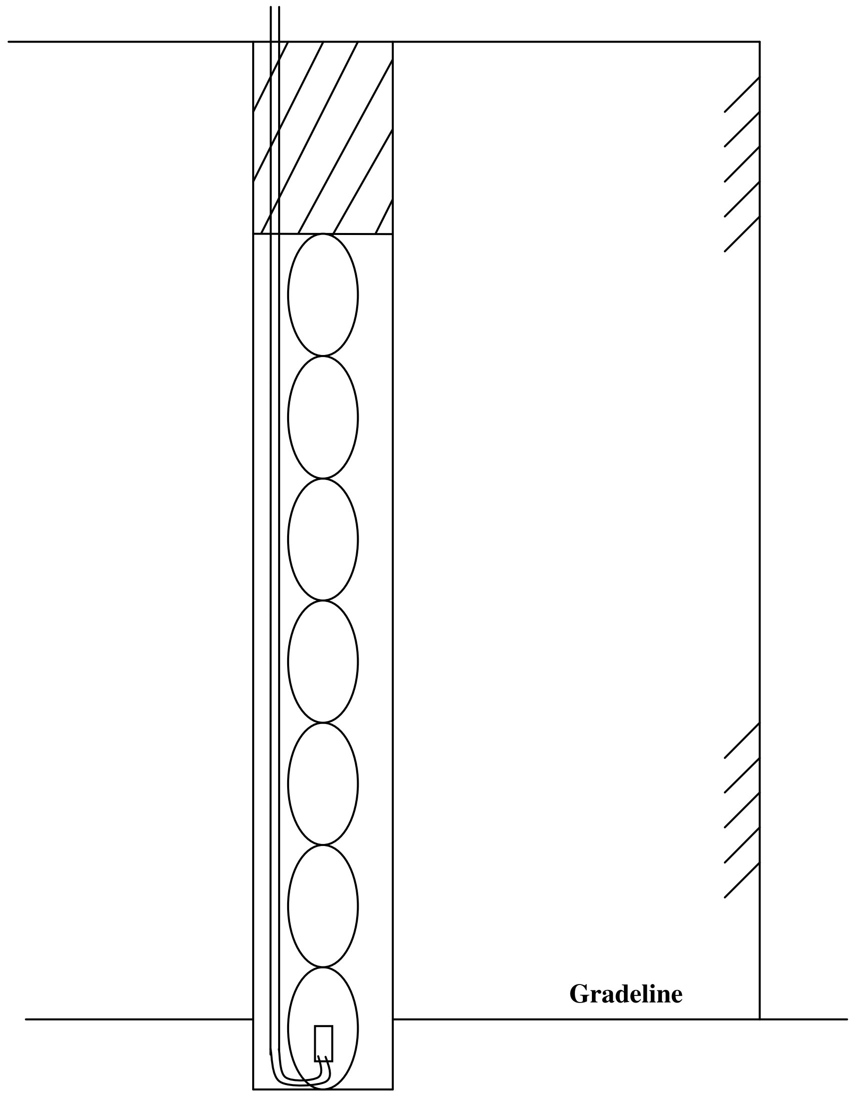
# Explosion

- ✓A chemical process where explosives changes its state and turns into gaseous energy



- ✓VOD – Velocity of Detonation

  How long it takes to get the chemical reaction completed and energy released.




**Charging Diagram**

# Explosives energy

- Work energy (EWK)

  Shock energy (shattering energy) derived from detonation pressure.

  gas energy (heaving energy)

  derived from gas volume expansion

- Waste energy

  Heat

  Light

  Sound

  Seismic

# Rock Blasting Mechanism

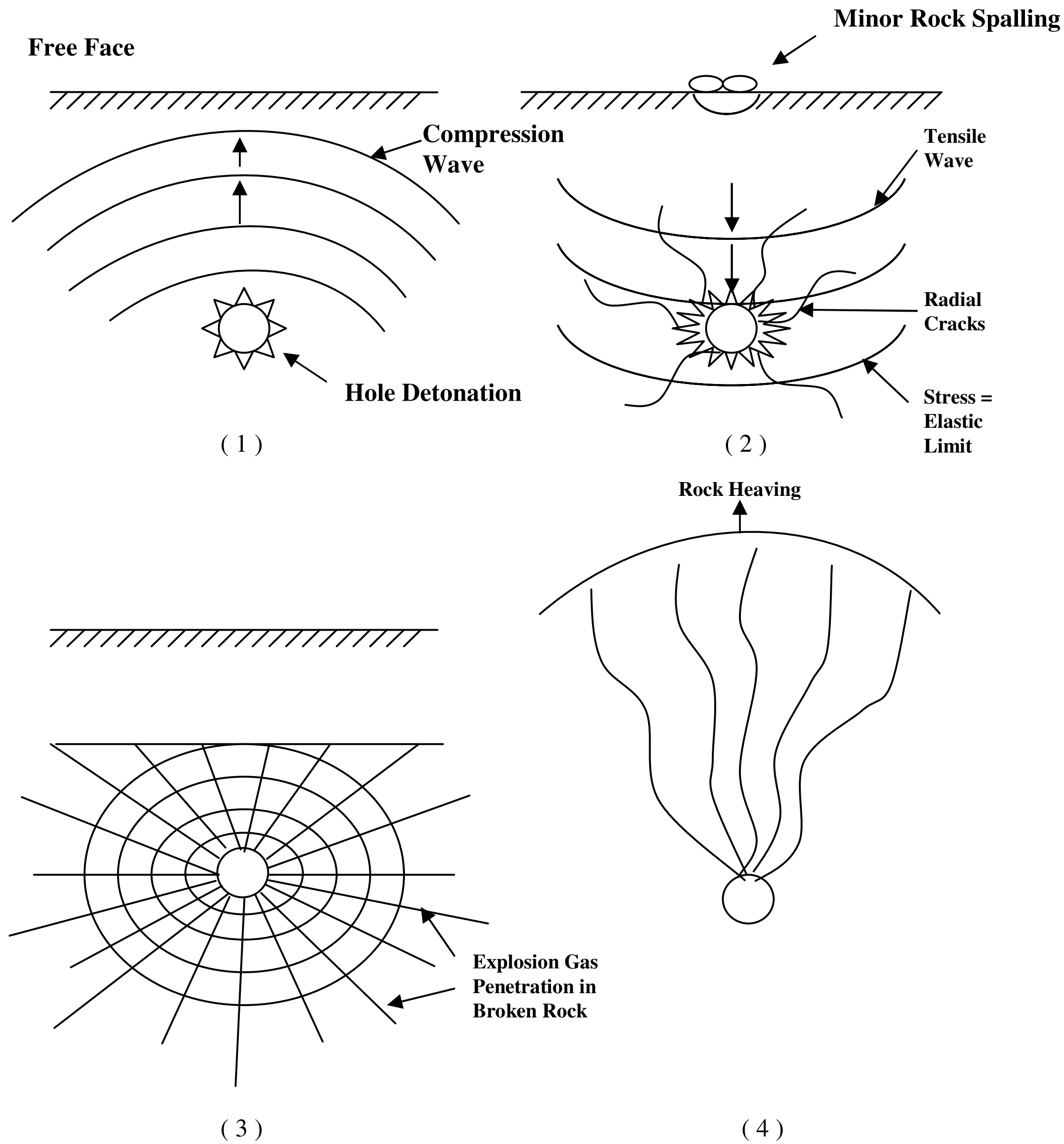
Rock Blasting Mechanism

Rock breakage happens when the shock energy intensity exceeds the elastic limit of the rockmass.

Young's modulas/Poisson's ratio

Fragmentation process

- Phenomeum of explosives detonation when buried in ground. (Consider scenario of dropping stone in a water pond)
- gas expansion inside borehole
- compression wave propagation outward
- tensile wave reflection back to blasthole area
- radial crack from borehole
- 1st stage - rock breakage happens – Brisane
- Gas penetration through fragmentation
- Once saturated, 2nd stage - heaving




**Rock Breakage Mechanism (Plan View)**

# Energy Dissipation

Intensity of stress/strain dissipated over distance. Once it falls below rockmass's elastic limit, it won't cause damage further to nearby rock, but serve a transmission path for seismic energy (waste energy forms of body wave and surface wave).

# For Surface Blasting - Where to blast drill blasthole??

a. Powder factor approximation

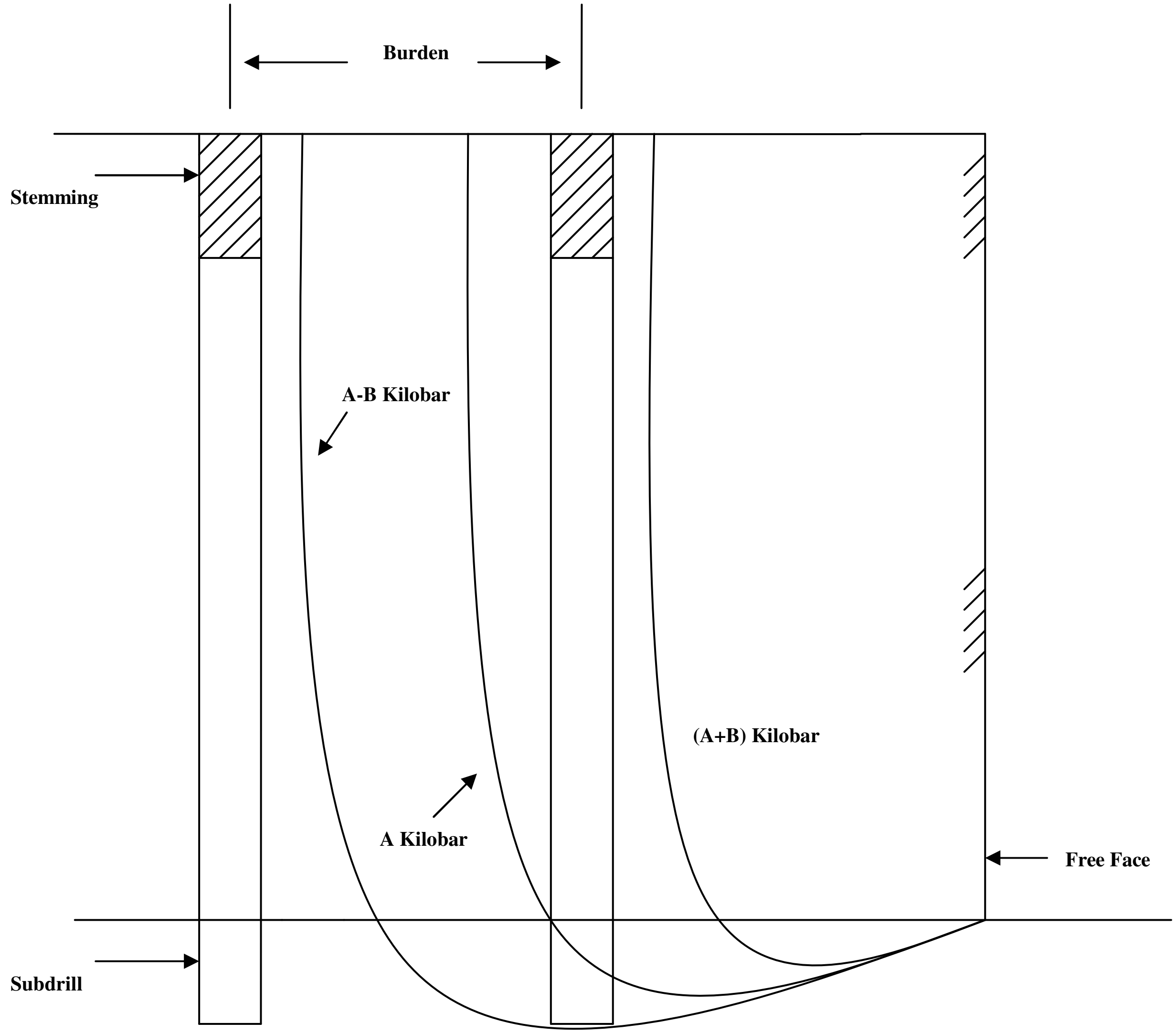
$$P.F. = \frac{\text{explosives load}}{\text{volume of rock}} = \frac{\text{explosives column x loading factor}}{\text{burden x spacing x bench height}}$$

Example: (granite blasting)
76mmØ borehole charged with 50mmØ explosives
10m bench
1m subdrill
2.5m stemming
Practice shows P.F. = 0.45 kg/m$^3$ in competent rock
Loading factor = 2.5kg/linear meter

$$\text{Burden x spacing} = \frac{(10+1-2.5) \times 2.5}{10 \times 0.45} = 4.4\text{m}^2$$

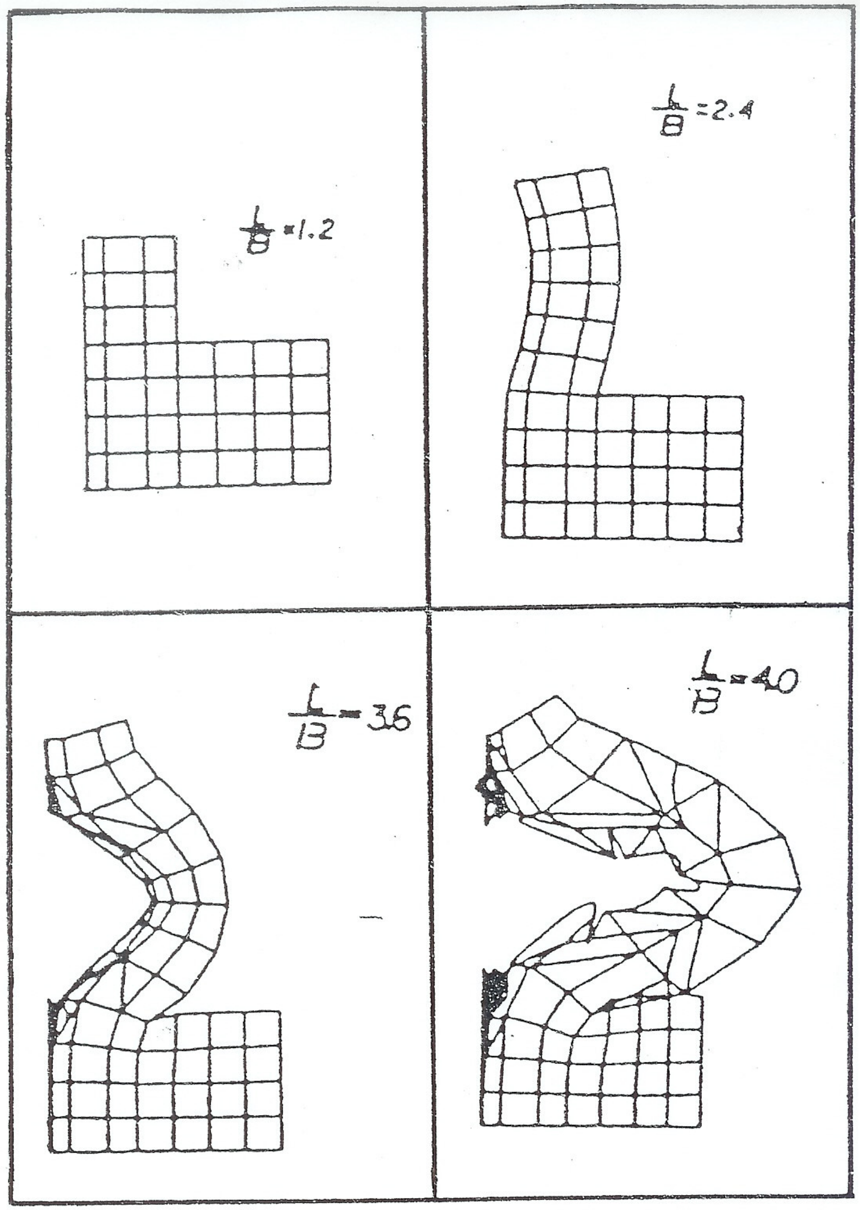
Burden = 2.1m
Spacing = 2.1m

b. Rock break contour concept




**A Kilobar = Rock Young's Modulas**

**( Section View )**




**Actual displacements**

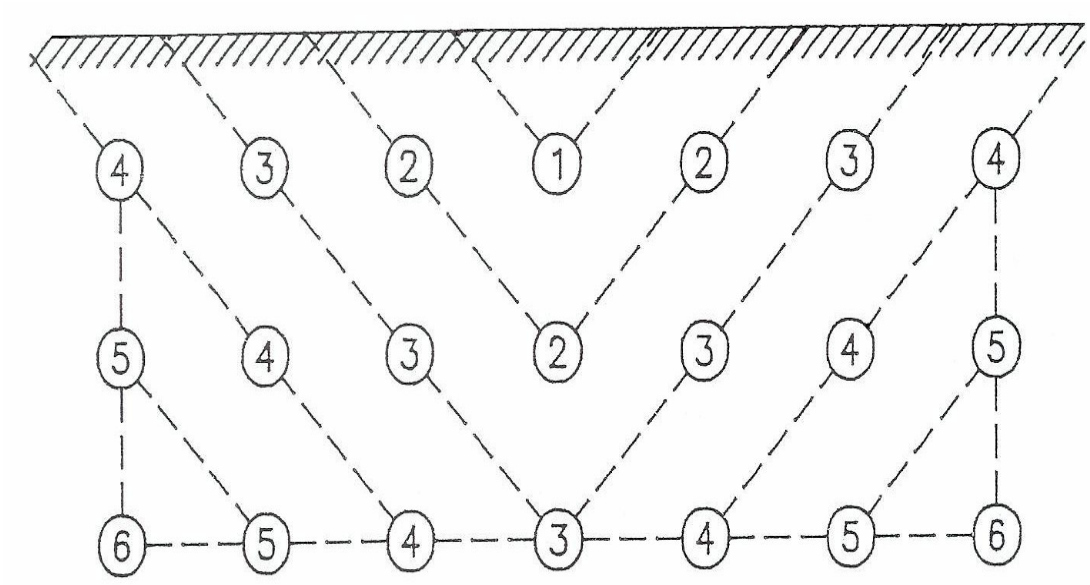
## Possible consequence of inappropriate drillhole location

a. Excessive high powder factor – short burden/spacing
   - excessive heaving in front (1st row)
   - long range horizontal/vertical flyrock from 2nd row onward due to back shatter from 1st row hole – no burden.
   - fragmentation too fine

b. Excessive low powder factor – great burden/spacing
   - toe problem (1st row) – insufficient front heaving
   - tendency to eject vertically on 2nd row onward
   - fragmentation blocky

# Variables that affects powder factor/drillhole location

1. geology – rock type/jointing status/fault zone
2. drilling deviation
3. explosives loading variance
4. firing sequencing




**V-cut ( square corner )**

# Importance of burden stiffness ratio consideration for flyrock

- rock heaving distance 1.5 to 2 bench height
- likelihood of flyrock to diameters of blasthole

small diameter hole - horizontal flyrock – overdigging

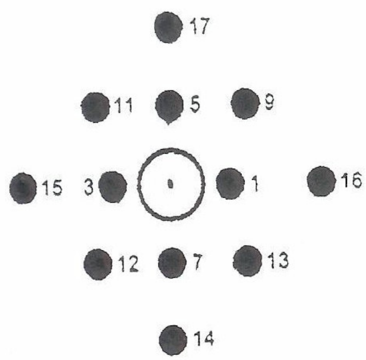
large diameter hole – vertical flyrock – inadequate heaving

# Tunnel Driving

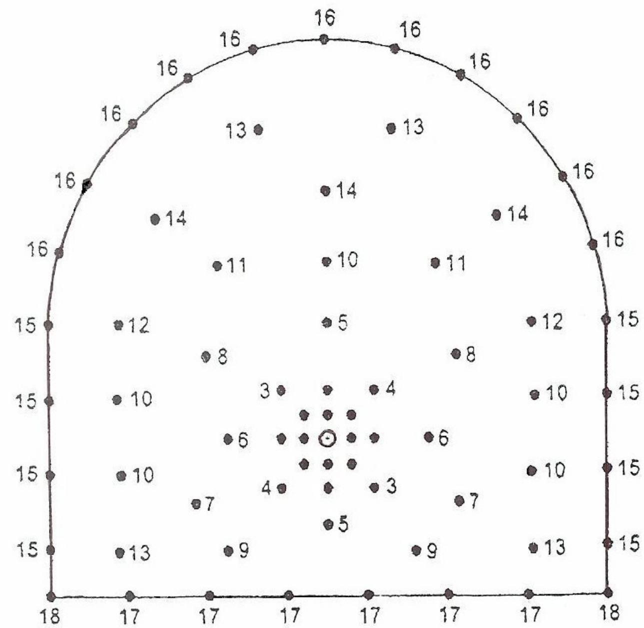
**Principle**

- Free face is placed at wrong direction
- Create a new internal free face in cut area by blasting with hard shattering, i.e. very high powder factor
- Delay the firing sequence toward the new internal free face

Millisecond Detonators




1/4 Second Detonators




6.2. EXAMPLE OF FIRING PATTERN WITH MILLISECOND AND ECOND DETONATORS - TUNNEL CROSS SECTION 30 SQ. M. EHOLE DIAMETER 45 MM

# Key Elements to Consider in Designing

- Cross section area
- Large section allows lower overall powder factor, but deeper advance per round
- Empty Holes space > 0.3 cut area
- Powder factor may be 5-10 times of overall higher than average
- Minimum delay timing between hole> $\frac{\text{0.5 depth}}{\text{Burden Velocity (30m/S)}}$ to avoid freezing
- More stemming is necessary in cut holes than other production holes

# Adjustment of blast design parameters

Observation of blast result for modification

- general fragmentation size, even ? (P.F. /wrong jointing orientation)
- oversized rock – in localised muckpile area? From surface (over- stemming?); bottom/toe (loading not to bottom/confinement?); inside muck (bad firing sequence, timing/misfire?)
- heaving distance/muckpile shape
- blast fume (explosives quality/water problem?)

# Conclusion

- ✓ *importance of blasting techniques*
- ✓ *identification of site specifics from field observation*
- ✓ *assessment based on blasting theories/and local knowledge*
- ✓ *judgement/changing to optimum*
- ✓ *apply "KISS" law*

Blind folded panic/action are helpless and would cause more danger