SURFACE MINING TECHNOLOGY

Semester: 3RD

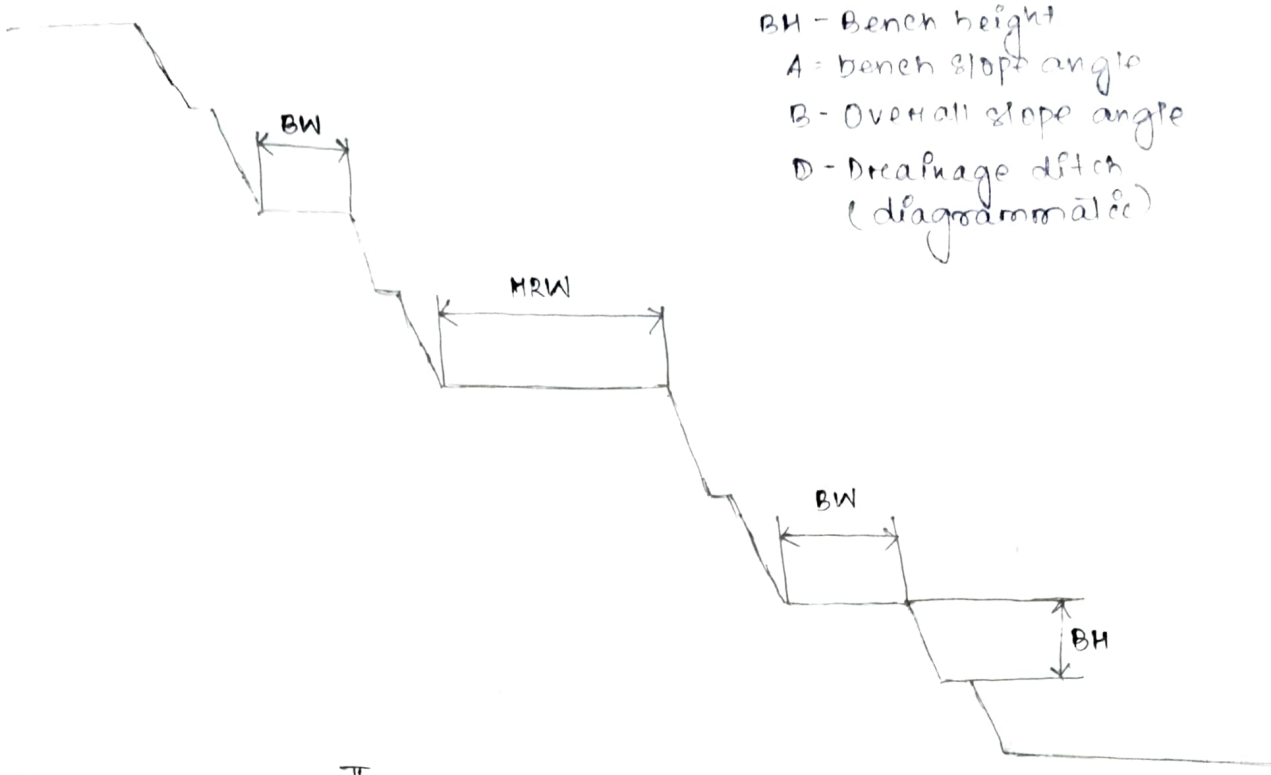
STUDY MATERIAL

SURFACE MINING TECHNOLOGY

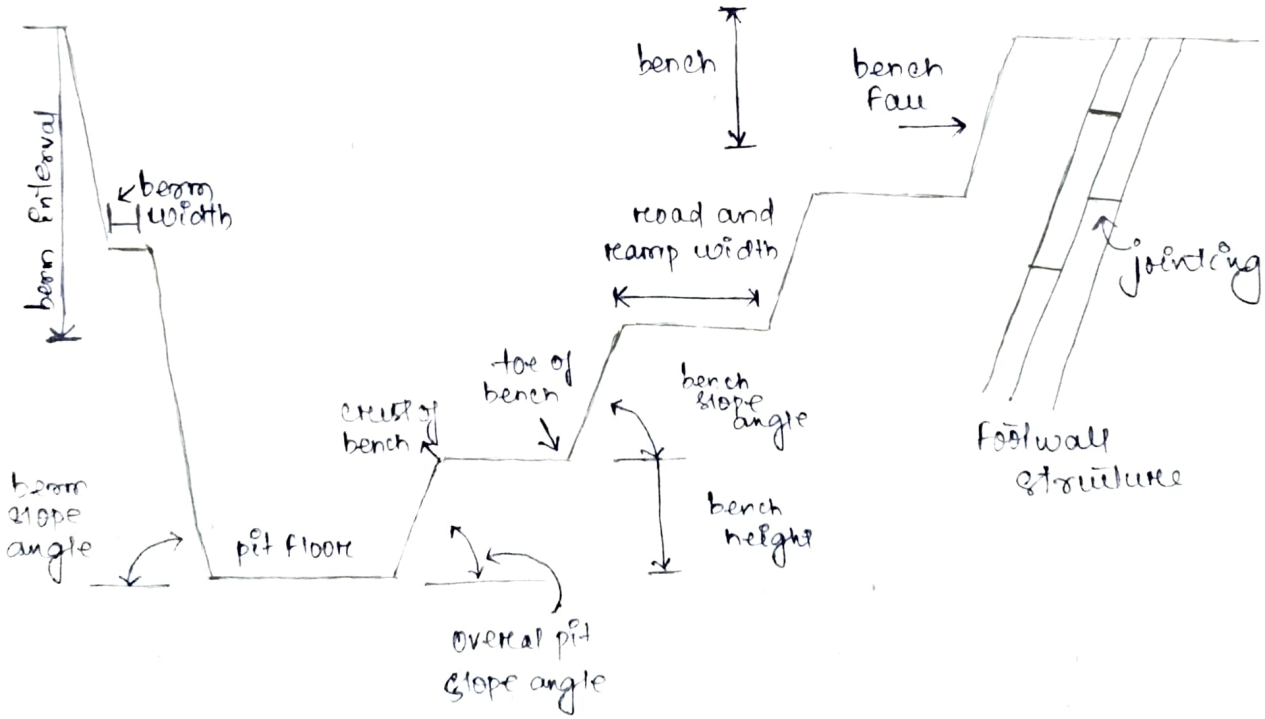
Mr Sanjay kumar Majhi
Lecturer
Department of Mining Engineering
IIPM School of Engineering & Technology Kansbahal, Rourkela, Odisha

Open Cast Terms

HRW - Haul road width
BW - Bench width
BH - Bench height
A = bench slope angle
B - Overall slope angle
D - Drainage ditch
(diagrammatic)



O/C Mining Terms



* MINING:- The process of excavating minerals of economic value from the earth crust for benefits of mankind is called mining.

MINERAL:- A homogeneous and naturally occurring substance having definite physical properties & a composition that may be expressed by chemical formula Ex:- pure forms:- gold, silver, some other minerals composed of two or more .... hematite, quartz, bauxite etc.

* FACTORS AFFECTING CHOICE OF O/C MINING:-
1. Shape and size of the opencast mine.
2. The angle of dip.
3. The local topography.
4. The physical and mechanical properties of the enclosing rocks.
5. The geological conditions.
6. The type of transport facilities.
7. The deposition of surface structures and plants (concentration plants, warehouse, stockpiles) directly related to mining operations.
8. Methods of working.
9. Availability of labour.
10. Use of HEMM/Mining operations/equipments.
11. Manner of blasting.
12. Stripping ratio & ~~mining~~ marketing condition.

* CONDITIONS FAVOURING ADOPTION OF MECHANIZED OPENCAST MINING:-
1. The deposit should be close to the surface. Formerly a depth of up to 90 m was considered to be the limiting depth in India. But with the advance of technology now opencast mining of coal is considered feasible up to about 200 m depth.
2. The ratio of overburden to coal should be less. A ratio of 4:1 is considered desirable but in some situations opencast mining up to a ratio of 8:1 is also considered economic. Abroad much higher ratio have been considered feasible.
3. The coal seam should be of uniform thickness and preferably flat.

4. The topography should be as level as possible. In hilly terrains, opencast mining method may entail considerable amount of overburden removal and also sufficient ground may not be available for the installation of facilities.

5. There should not be excessive make of water : sites where artesian aquifers are encountered create problems. Also sites close to the sea may get heavy seepage in the workings.

6. A mild climatic condition is generally favoured : with excessive rain or heat or cold the mining operations are hampered.

* STRIPPING RATIO :- It is the ratio of thickness of mineral deposit to the thickness of the over burden. It may be also defined as the ratio of weight of recoverable mineral reserve in tonne to volume of overburden in cu. meter.

* FACTORS AFFECTING STRIPPING RATIO :-

- Sale value of mineral.
- % of gangue.
- Methods of working
- Transport cost.
- Nature of overburden
- Grade of ore body

* QUARRIABLE LIMIT :- The cost of removing overburden to extract mineral lying below it goes up as the quarrying operations extend to the dip side of the property and the thickness of overburden increases. The stripping ratio, thickness of overburden : thickness of mineral deposit thereafter decides the economic working limit of quarrying, i.e., the quarriable limit. The softer the rock, the less is the expense of overburden removal and higher is the stripping ratio.

- Manual quarrying 1.5:1
- Semi-mechanised quarrying 2:1
- Mechanised quarrying :
  - with dipper-shovel, dumper combination; 4 to 5:1
  - with dragline : 8 to 10:1
  - with bucket wheel excavators. 3 to 4:1

- The maximum depth from the surface in existing mines in our country is 120m but future mines are planned to reach a depth of nearly 450m.

* LIMITATION OF LARGE O/C OR OPEN PITS :-

- The method may be uneconomic for extracting minerals at greater depth.
- There may be huge environmental problems.
- Degradation of surface land.
- Weather affects the worlle.
- Higher investment on equipments in the mechanized opencast mine
- Limited by the stripping ratio.
- Requires large & extensive deposits for high capacity mechanised O/C mines.
- Stability of bench slope should always be maintained.
- Requires a remote area for mine waste disposal.
- Requires careful sequencing of methods of operations.

* BOX CUT :- Opening up of open pits done by an opening cut for the developing of first working bench with slope of suitable gradient is called box cut. It is an in-going entrance or opening trench. This is a trench providing access from the ground surface to the working horizon of an open pits or approach from one of the active parts of a deposit to another.

* LOCATION OF BOX CUT :-

- Minimum cost of ~~huge~~ haulage within the open pit & outside the pit to the desired places.
- In dipping deposit : location of the box cut should be in the middle to the reserve.
- In horizontal deposit : The box cut can be located in middle deposit.
- It should be stable & free from geological disturbance.
- It should be selected where construction of approach road is very convenient.

- It should be selected where the deposit has high grade mineral to compensate the development cost.
- It should be such that it serves the purpose of maximum mining area.
- It should be sufficient enough to diversify the approach road to all benches.

* BENCH TERMINOLOGY :-

BENCH :- An exposed rock/mineral block separated by upper and lower surface is called bench.

- BENCH HEIGHT :- The vertical distance between the upper and lower surface of each
- BENCH FACE :- The exposed sub vertical surface of bench is called bench face.
- BENCH ANGLE :- The average angle that the bench face makes with the horizontal is called the face angle.
- BENCH FLOOR :- The exposed bench lower surface is called the bench floor.

- BENCH WIDTH :- The distance between the crest and the toe measured along the upper surface is called the bench width.
- CUT :- The width being extracted from the working bench is called cut.
- SAFETY / CATCH BENCH :- After the removal of cut the remainder of the bench is called the safety bench.
- BERM :- Piles of ~~working~~ broken rock, ~~mineral~~ materials constructed along the crest to improve mine safety is called berm. Height of the berm generally kept higher than the radius of the tyre of the truck / dumper.
- CREAST :- The upper side of a face of a bench is known as crest.
- TOE / FOOT :- The lower side of a face of bench along its length is known as toe.
- BENCH SLOPE ANGLE :- The angle which the face of particular bench makes with the horizontal is known as bench slope.
- OVERAL / PIT SLOPE ANGLE :- The angle which an imaginary line makes with the horizontal the lower point of this line being at the foot of lower most bench and upper point being the crest of the top most bench is called pit slope angle.

* HEIGHT AND WIDTH OF BENCH AND HAUL ROAD

Slope of side of mine - Bench slope angle.

R 106 1a

a. In alluvial soil, moram, gravel, clay, debris or other similar ground R 106 1a

(i) Height of Bench = 1.5 mtr

(ii) Width of Bench = Height of Bench.

(iii) Slope of side of mine = 45 degree.

b. For float and similar deposit (manual ~~forming~~ mining)

(i) Height of Bench = 6 mtr

(ii) Width of Bench = Height of Bench

(iii) Slope of side of mine = 60 degree

c. For compact / hard rock deposit (manual mining)

(i) Height of Bench = 7.5 mtr

(ii) Width of Bench = Height of bench

(iii) Slope of sides of mine = 60 degree

1. DGMS Cir. 36/1972 & Tech 17/1977

(i) Height of Bench = not more than digging height of m/c in case of uniformly soft rock - the DI may permit the extension of the height upto 3 mtr above the digging height of the machine.

(ii) Width of any bench shall not be less than -

a. Width of the widest machine plying on the bench slope plus 2m,

b. One fg dumpers ply on the bench, 3 times the width of the dumper.

c. One - th height of the bench whichever is more.

2. DGMS Tech. circular 09 of 2008

(i) Width of haul road = not less than 3 times + 5m width of the largest vehicle.

(ii) All curves and bends = not less than 3 times the banking distance of largest HEMM working at 40 km/hour.

(iii) Where it is not possible provided with two roads of width not less than 2 times plus 3m of largest vehicle playing on the road divider at center with adequate lighting.

(iv) Where any road existing above level of surrounding area, provided with a strong parapet wall / embankment of following dimensions:

a. Width at top not less than 1m,

b. Width at bottom not less than 2.5m,

c. Height not less than the diameter of tyres of largest vehicle.

(v) No road shall have gradient more than 1 in 16. Ramp with 1 in 10 gradient should not be more than 10m at one stretch and permission shall be obtained from Directorate.

* Slope stability = $\frac{\text{Shear strength}}{\text{Shear stress}}$

Slope stability problem is greatest problem faced by the open pit mining industry. The scale of slope stability problem is divided on two types:-

→ Gross stability problem: It refers to large volume of material which come down the slope due to large rotational type of shear failure and it involves deeply weathered rock & soil.

→ Local stability problem: This problem which refers to much smaller volume of material and these type of failure effect one or two benches at a time due to shear plane jointing, slope erosion due to surface drainage.

* Factors affecting slope stability:

→ Slope Geometry: (i) Bench height
(ii) Overall slope angle (45°-90°)
(iii) Area of failure surface

→ Geological structure: (i) Amount & Direction of Dip.
(ii) Intra-formational shear zones.
(iii) Joints and Discontinuities
(iv) Fault

→ Lithology:

→ Ground water

→ Mining method and Equipment

→ Dynamic forces

→ Angle of internal friction

* Slope stability: The potential of soil covered slopes to withstand and undergo movement is called slope stability.

MINERAL RESOURCES:

* A mineral resource is a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form and quantity that there are reasonable prospects for eventual economic extraction.

* The geological characteristics of a Mineral Resource (such as location, quantity, grade and continuity) are known estimated or interpreted from specific geological evidence and knowledge.

* Mineral Resources are those economic mineral concentration that have undergone enough scrutiny to quantify their contained metal to a certain degree.

MINERAL RESOURCE CLASSIFICATION:

Mineral Resources are further categorised based on the level of confidence into (lowest to highest)

a) Inferred Mineral Resources
b) Indicated Mineral Resources and
c) Measured Mineral Resources

a. Inferred Mineral Resources:

* An inferred mineral resource is that part of a Mineral Resource for which tonnage, grade and mineral content (quantity and grade or quality in the CIM standards) can be estimated based on, may be limited or of uncertain quantity and reliability.

* It has a lower level of confidence than that applying to an indicated Mineral Resource. Due to the uncertainty attached to inferred Mineral Resources, it cannot be assumed that all or a portion of such resources will be upgraded to an indicated or Measured Mineral Resource as a result of more exploration.

* Estimates are based on an assumed continuity beyond measured and/or indicated resources, for which there be geologic evidence. Inferred resources may or may not be supported by samples or measurements.

* This category implies a degree of uncertainty and is used in cases where there is good geological evidence for continuity, but only a limited amount of sample data such as four widely spaced boreholes.

b. Indicated Mineral Resources:

* An indicated mineral resource is that part of a mineral resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a reasonable level of confidence. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed. This category has a confidence level higher than inferred Mineral Resources but a lower confidence level than Measured.

* Quantity and grade and (or) quality are computed from information similar to that used for measured resources, but less for inspection, sampling and measurement are further apart or are otherwise less adequately spaced. The degree of assurance, although lower than for the measured resources is high enough to assume continuity between points of observation

c. Measured Mineral Resources:

* Measured resources are indicated that have undergone enough further sampling that a competent person's (defined by the norms of the relevant mining code; usually a geologist) has declared them to be an acceptable estimate, at a high degree of confidence, of the grade, tonnage, shape, densities

* A measured Mineral Resource is estimated in the same manner as an Indicated Mineral Resource, except that:

(i) It can be estimated with a high level of confidence.

(ii) The information must be detailed and reliable and

(iii) The locations are spaced closely enough to confirm geological and/or grade continuity.

MINERAL RESERVE (OR ORE RESERVES)

* A mineral occurrence that is deemed to be valuable after considering mining, metallurgical, economic, marketing, legal, environmental, social, governmental and other factors (the modifying factors) to determine the viability of an asset.

* Natural resources that have been discovered & can be exploited profitably with existing technology.

Mineral reserves are resources known to be economically feasible for extraction.

Mineral Reserves are further categorised based on the level of confidence into (lowest to highest).

a) Probable: The economically mineable part of an indicated and in some circumstances, Measured Mineral Resource.

b) Proven: The economically mineable part of a Measured Mineral Resource.

TYPES OF SLOPE FAILURES

* There are main four types of failures which are:-

1. Plane failures
2. Wedge failures
3. Toppling failures
4. Rotational failures

- **PLANE FAILURE**

* A rock slope undergoes this mode of failure when combinations of discontinuities in the rock mass form blocks or wedges within the rock which are free to move.

* The pattern of the discontinuities may be comprised of single discontinuity or a pair of discontinuities that intersect each other, or a combination of multiple discontinuities that are linked together to form a failure mode.

* A plane failure of rock slope occurs when a mass of rock in a steep slope slides down along a relatively planar failure surface. The failure surfaces are usually structural discontinuities such as bedding planes, faults, joints or the interface between bedrock and an overlying layer of weathered rock.

- **WEDGE FAILURE :-**

* Wedge failure can occur in rock mass with two or more sets of discontinuities whose lines of intersection are approximately perpendicular to the strike of the slope and dip towards the plane of the slope.
* This mode of failure requires that the dip angle of at least one joint intersect is greater than the friction angle of the joint surfaces and that the line of joint intersection intersects the plane of the slope.

- **TOPPLING FAILURE**

* Toppling failure occurs when columns of rock, formed by steeply dipping discontinuities in the rock rotates about an essentially fixed point at a near the base of the slope followed by slippage between the layers.
* The centre of gravity of the column or slab must fall outside the dimension of its base in toppling failure.
* Jointed rock mass closely spaced and steeply dipping discontinuity sets that dip away from the slope surface are necessary prerequisites for toppling failure.

- **ROTATIONAL FAILURE**

* In rotational slips the shape of the failure surface in section may be a circular arc or a non-circular curve.
* In general, circular slips are associated with homogeneous conditions.
* Translational and compound slip occurs where the form of the failure surface is influenced by the presence of an adjacent stratum of significantly different strength.

ORE RESERVE

→ Tonnage :- Metal content that can be extracted.
= volm × sp. gravity (Area × thickness of ore × sp. gravity)
= volm × Buck density.

→ Avg. grade :- Avg. metal content in ore.

→ cut off grade :- Above this grade mining is profitable

→ Assay value :- Avg. metal content in ore. It is used in precious mineral/metal.
Assay: process of determing metal content.

* Method :-
→ Grid pattern
→ Triangular
→ polygonal
→ inverse distance surveying method
→ Cross-section method
→ LV-section
→ Isopach map

* Grid pattern or square pattern
→ bedded, sheet, flat type deposite.
→ Adjacent hole fixed (Exp- in mine ~ 100m)
• Avg thickness, volm, Tonnage.
→ Area = dd × $\left(\frac{t_1 \times t_2 \times t_3 \times t_4}{4}\right)$ Avg-thickness
→ volm for each block = Σvlm
• Tonnage
→ Avg. grade : $\frac{G_1 t_1 + G_2 t_2 + G_3 t_3 \ldots G_n t_n}{\Sigma t_n}$

* Triangulation Method :-
* Tonnage = [V] × sp. gravity
V = [Area] × Avg. thickness
• Area = $\sqrt{s(s-a)(s-b)(s-c)}$
→ $s = \frac{1}{2}(a+b+c)$
• Avg. thickness = $\frac{a(t_1+t_2) + b(t_3+t_2) + c(t_2+t_1)}{2(a+b+c)}$

- Grade = $\frac{a(g_2t_2+g_1t_1)+b(g_3t_3+g_2t_2)+c(g_2t_2+g_1t_1)}{a(t_1+t_2)+b(t_3+t_2)+c(t_2+t_1)}$

- Avg. grade = $\frac{\Sigma G_i \times T_i}{\text{No. of blocks / Triangles}}$

- $\frac{\Sigma G_i \times T_i}{\Sigma T_i}$

Bench Height :-

* Advantages - largere height
  - Efficiency of shovel in increased
  - Minimize amount of tipping and levelling of floor.
  - Efficiency of transport system is improved.
  - Larger blast and higher productivity.

* Disadvantages - largere height
  - Slope failure is increased.
  - Supervision of benches are difficult.
  - Deep hole blasting may yield oversized ore/rock.
  - Severe damage of machinary & serious accident of workers may occure due to greater momentum.

* Length of face :-

Determination of number of face required for a target production of 'Y' in annum.

Assume:

Height of Bench - H, width of bench - W

Spacing = S, Burden = B

Bulk Density / Sp. gravity = Y, working days per year = D

working hrs per week = 6

Length of face = L, Two rows of blasting in round = 2x6

→ production per hole = $H \times B \times S \times Y$ ——(a)

→ production per week = $\frac{Y \times 6}{D}$

→ so number of holes required per week = $\frac{(Y \times 6)/D}{H \times B \times S \times Y}$

$= Y \times 6 / D \times H \times B \times S \times Y$ — (1)

→ length of jaw required (L):-

$$L = \frac{Y \times 6}{D \times H \times B \times S \times Y} \times \frac{\text{Spacing (1)}}{\text{No of rows (2)}}$$

$$= \frac{Y \times 6 \times 1}{2 \times H \times 6 \times S \times Y \times D} = \frac{Y \times 3}{H \times B \times Y \times D}$$

→ For production at shovel jaw of the same length is required for drilling at the same time.

- length of the jaw (L) = $\frac{Y \times 3 \times 2}{H \times B \times Y \times D}$
- Nos of Bench required = $\frac{Y \times 3 \times 2}{H \times B \times Y \times D} \times \frac{1}{L}$

$$= \frac{Y \times 6}{H \times B \times D \times L \times Y}$$

* Causes of slope stability :- (failure)

→ Gravitational force
→ Force due to seepage water
→ Erosion of the surface of slopes due to flowing water
→ Force due to earthquake
→ The sudden lowering of water adjacent to slope.

* Prevention of slope stability :- (failure)

→ A surface drainage system that is capable to discharge all the storm water.
→ A surface drainage system usually consists of
  - surface channel
  - stepped channel
  - catch pit

→ protection & treatment to rock slope.
→ Lowered Bitrels support.

→ Meshing or meting
→ Rock Bolt nail
→ Vegetational biological
→ Nylon Blanuels

EXPLOSIVES AND BLASTING ACESSORIES

* Definition of Explosives:- Explosive is a chemical compound of mixtures, when exploded by action of heat, impact & gives larger volume of gases in a very short time at high temperature & pressure.

* Detonation:- It is a proces of giving a suffient violent shock to the explosive to bring about an instantaneous rearrangement of atoms.

* Explosive mixture contains:
1. Combustile matter - wood meal, fibre, sulphur, charcol etc.
2. Oxiding agent - sodium nitrate, ammonium nitrate, potassium nitrate.
3. Stabilisers - magnesium & calcium carbonates.
4. Antisetting agent - To prevent caking of salts.
5. Sensitizers - Metallic powders.

* Properties & characteristics Explosive
1. Sensitivity
2. Density
3. Water Resistance
4. Velocity of Detonation (VOD)
5. Weight Strength
6. Fume characteristics
7. Thermal stability

* 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 from 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 & 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.

$$\text{Relative Bulk strength} = \frac{\text{Relative wt. strength} \times \text{Density}}{\text{Density of ANFO}}$$

* Water Resistance: Explosive differ widely in resistance to water and moisture penetration. Some explosives deteriorate rapidly under wet condition, but others are designed to withstand water for long periods.

* Sensitivity: An explosives is required to be insensitive to normal handling, shock and friction, but must remain sufficiently sensitive to satisfactorily detonated and capable of propagating satisfactorily, cartridge to cartridge, even over gaps such as may occure 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 charge if the charges if the temperature in the borehole exceeds 30° when blasting in hot ground.)

* Classification: All commercial explosive 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 accompaying any shock wave.

- It gives a heaving effect.
- Not used in wet places & in u/g coal mines.
- Example: Gun powder
- Chemical composition: Sodium Nitrate - 72%
  Sulphur : 12%
  coal : 16%
- Gun powder fired by safety fuse.

* High Explosives: Reaction in high Explosives is characterised by an associated shock wave initiated by a detonator.
* It basically contains:
- Oxidizers - Such as Ammonium Nitrate fuel oil.
- Sensitizers: Methyle Amine.
* Nitrate, Per chlorate salt
- Sensitizer: Entrapped Air Bubbles
- It gives shattering effect.
* Example: Nitrate mixtures, PETN, TNT, Nitro compounds, Blasting gelatine, Liquid oxygen Explosive.

According to explosive rules the explosives and their accessories are classified into eight classes.
There are:
* Class 1: Gunpowders
* Class 2: Nitrate mixtures (like ANFO, Aquadyne, Energel, DN-1, Gelodyne, Permadyne, powergrow, Permagrow, Powderite, Superdyne, supergel, Tovblast.)
* Class 3: Nitro compounds Div:1: Blasting gelatine, special gelatine, O.C. G., Ajax - G, Viking - G, sawyer, etc. Div: 2; Cyclotol, PETN, TNT etc.
* Class 4: Chlorate mixtures
* Class 5: Fluminate
* Class 6: Ammunition Div:1: safety fuse, Igniter cord, connectors, Electric lighters etc. Div: 2: detonators, Detonating fuse, plastic igniter cord, fuse igniters, etc. Div: 3: Detonators, delay detonator, relays etc.
* Class 7: Fireworks.
* Class 8: Liquid oxygen Explosive (LOX)

The commonly used explosives in the opencast mines of our country are:

* Ammonium Nitrate: It is a very explosive and [illegible] oxidizing and cooling agent and very safe to handle. It is mixed with a [illegible] sensitizer (fuel oil or NG or Trinitrotoluene) to form an explosive. It is hygroscopic in nature. It is having low [illegible] to detonation and less power as compared to NG. It is cheap, safe to handle and give better fragmentation. Prilled AN of fertilizer grade mixed with diesel oil is used for larger diameter hole in opencast mines.

* Ammonium Nitrate and fuel oil: It is a mixture of prilled AN and fuel oil, at the nearly oxygen balanced ratio of 94/6 AN/FO. Both sensitivity and performance depend upon prill properties. It does not detonate ideally and its performance properties depend upon charge diameter and confinement. For dry hole condition it is excellent, and also it should be initiated as soon as it is loaded. It is initiated by small quantity of D.C.G as booster.

* Slurry explosive: The type of explosive incorporate besides oxidizer (AN, sodium Nitrate etc) water, sensitizer hydrophilic colloid which results in viscosity build up of the matrix. Water resistance is due to the cross-linking agent forms a network of bonds ~~having~~ involving the polyvalent metal ion and hydrated gum molecules. Proper density control is crucial for maximizing the shock sensitivity of these explosives. These are the agent of all explosives as they are not ignited easily and insensitive to any type of shock, bullet, impact and friction. It has good ~~time~~ fume properties, water resistant. Slurry automation is accomplished by pump truck method. It is the successful field implementation of SMS (site mixed slurry) concept. It gives a high loading rate (150-300 kg/min) and minimize the blasting efficiency.

* Site mixed slurry: These explosive are used for blasting on a large scale in an opencast mine. It involves specially designed pump trucks for transport to the blasting site integrated ~~to~~ required for SMS system. It basically comprises a mixer support plant where intermediate non explosive slurry is initially prepared for its application. This intermediate slurry subsequently, is transferred to a 10 tonne capacity [illegible] tank.

* Emulsion Explosive: It is a mixture of oxidizer and fuel which are both in liquid form. With the help of emulsifying agent an intimate mix of oil and water is possible. Delivery rate of 200 - 300 kg/min can be achieved. Load cells/digital meters indicate amount explosive being loaded into boreholes. Straight emulsion explosive has high bulk strength. Emulsion matrix can be carried in support tankers of 10-12 tones capacity or more which is transferred at site thus saving time. It ensures uninterrupted charging. It is recommended that 500 gm pentolite boosters are used for boosting. Manpower savings are obtained with less deployment of van drivers or helper, blasting crew and magazine staff. Full borehole coupling expanded burden/spacing parameters or blasting efficiency. It does not give explosive pilferage.

* Heavy ANFO: It is latest development of 1980's had been use of emulsion slurries mixed with different proportion of ANFO. The ratio of emulsion to ANFO is 20:80 to 50:50 depending on the severity of water conditions and need to stronger blast energy. It is of low cost with higher density, higher energy and better water resistance than ANFO and AN. The concentrate system allows expansion of drilling pattern, thereby reducing drilling cost. The comparative VOD of ANFO, slurries and emulsion are 2000 to 4200 m/s, 3300 m/s and 5000 to 6000 m/s.

ACCESSORIES :-

* Detonator: High explosives are initiated by detonator or detonating fuses. It is a small auxiliary charge of special explosive. Due to chemical reaction initiated by flame or electric current in the special explosives, an explosion of sufficient intensity results throughout the high explosive enclosing the detonator. It is of plain ordinary electric detonators. It is having a ⅓rd with A.S.A composition and P.E.T.N. No.6 detonator is suitable for normal requirement of mining work. No.8 is more powerful than No.6. The current of 0.5 amp is required for ignition of fuse-head so single detonator can blasted with minimum voltage of 3.5 volt. Delay detonator is used for more efficient blasting due to supply of immediate fuse fail for multiple blasting.

* Booster: For effective detonation of slurry explosives and ANFO mixtures such as GN-1, use of high detonation velocity booster is necessary. It is water resistant and VOD of 7000 m/s, wet strength 82 and can be detonated by detonating fuse or detonator. Cast booster is not substitute for explosive charge. It is a very powerful detonator of large size and is required for deep large diameter, blast hole in opencast mines.

* Safety fuse: It looks like a cord consists of core fine grained gunpowder warped with layers of a tape or textile yarn and water proof coating.

* Detonating fuse: For shallow depth (3m) and for small number of holes, a detonator is inserted in the cartridge itself and detonator by ignition of safety fuse or in case of electric detonator, by an exploder. It contains core of PETN enclosed in a tap wrapped with cloth. It looks like a plastic cord. Its diameter is 5mm external and weight about 20 g/m length. It has a VOD of 6500 m/s. A large number of shots connected with detonating fuse can be blasted by a single detonator. Nonel is non-electric detonator.

* Detonating Relays: In opencast working. It use detonating fuse for initiation provide a non electric delay firing system. It avoids electrical connection which are required when using delay detonators. A detonating relay is an assembly of two open ended delay detonator coupled together with flexible neoprene tubing in an Aluminium sleeve. The delay interval for each detonating relay varies from 15-14 milliseconds. In use, the main or branch line of detonating fuse cut at required point of delay and detonating relay is crimped between two cut ends of the line. Cord relays manufactured by IDL chemicals.

* Circuit Tester: The blasting circuit is tested by circuit testers because to avoid accidental explosion of detonator. blastmeter is manufactured by IDL chemical. It is an electronic solid circuit tester.

* Crimper: A crimper is a paid ● to crimp or press the end of the detonators tube or safety fuse so that fuse cannot come out from the detonators. Short firing cables: During electric shot firing the leads for the detonators are connected to long shot firing cables to fire the shots from safe distance.

* Exploder: The portable apparatus which provide the current necessary for firing electric detonator is called exploder. There are three type of exploder used in Indian mines i.e. Magneto (or Dynamo exploder, Battery condenser dynamo Exploder.

* Nonel: Non electric detonator (developed by nonel AB of sweden)

→ The flexible plastic tube has 3mm external and internal 1.5mm internal diameter. One end of tube is fitted with a non-electric delay detonation which is crimped it to the factory while other end is sealed.

→ The end having detonator is lowered down into the blast hole while the sealed and projects outside the hole. The sealed end is initied by detonator or lord.

→ VOD = 2000m/sec. which has sufficient energy to initiate the primary explosive or delay element in a detonator. Acts a signal conducter.

* Advantages:-

→ Eliminates the need for complicated electrical circuit testing & shot firing equipment.

→ It prevents vibrations, fly rock, air blast, noise & misfire.

→ Resistance to accidental initiation by static electricity, stray current, radio transmissions flashe, friction and impact.