LEARNING MATERIAL

SEMESTER : 3RD SEMESTER

BRANCH : MINING ENGINEERING

THEORY SUBJECT : SURFACE MININGTECHNOLOGY (TH – 1)

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SURFACE MINING TECHNOLOGY

1.0 INTRODUCTION TO MINING

ADIT: It is a horizontal entry to the ore body in the hill when one end of the entry is open to atmosphere. The ore body is concealed in the hill. The horizontal road is leading to the ore body. One end of the entry to ore body is open to atmosphere. The underground working are carried of the ore body from the other end of the entry. The broken ore is carried out of the mine by this entry. Such entry is known as adit. The position of ht lowest adit is at the ground level. The other adits can be set at different levels from ground level. Thus it is posoble to work the complete height of the ore body in hill above the ground level. The broken ore is transported out of the mine through these adis. Workers use these entries to reach the working within the hill.

INCLINE: When the ore body is outcropping or close to surface, the ore body is approached by an incline roadway which is known as incline. The roadway leads from surface to underground by incline road. The ore body is worked by the underground mining from this incline roadway.

Advantages:

1. It is simple approach from surface to under ground working.
2. It is direct approach to under ground working.
3. It is less costly approach to underground working.
4. It provides less costly transport of ore from underground to surface.
5. It has less cost of sinking compared to shaft.
6. It has less maintenance cost than that of shaft.
7. It does not require costly headgear structure as required by shaft.
8. It does not require costly winding engine as in case of shaft.

Disadvantages:

1. It is not suitable when ore body is at more depth.

3. The length of drivage is more than shaft.

4. The maintenance cost is high when it is driven through unstable ground and weak stratas.

SHAFTS: It is an entry or exit from or to surface to or from underground, OR. It is an entry or exit from or to underground to or from underground. When the ore body or coal seam is at greater depth from surface, the underground workings are approached through a shaft only. It is excavation of limited diameter to reach the ore body or coal seam. This entry to underground or the exit from underground is either vertical or incline or sometimes compound. In compound entry the vertical shaft is connected to inclined shaft. In maximum cases the vertical shaft is preferred. The shaft is in the centre of coal seam or vast ore property. The workings are approached from shaft. The distances of workings are nearly equal on all sides. Thus the transport distances are nearly equal on all sides. Thus the transport distances are nearly same in all directions and are economical. Generally the shaft is located 2/3 distance away from dip 1/3 from rise ends. The shaft is vertical in case of horizontal ore body or coal seam. It is vertical in case of low inclination. The vertical or inclined shaft is used in case of highly inclined ore body. The distance of shaft from ore body is not same in case of the inclined ore body from the vertical shaft. The distance of inclined shaft is constant in case of highly inclined ore body at different depth.

2.0 EXLOSIVE AND BLASTING ACCESSORIES

2.1 Define explosive, state constituent of explosives and properties of explosives.

EXPLOSIVES:- Explosive is a solid, liquid or mixture of substances those containing large chemical energy that can be quickly converted into heat and mechanical work

instantaneously get converted to gases. During this conversion the heat is generated and the process of conversion become more instantaneous. The gases procuced require much more large volume than original volume of explosive.when the explosive is placed in confinement the gases do not get large space. Thus gases build up pressure under the confinement. The large amount of gases produced build high pressure. This high pressure is more than the rapturing capacity of the surrounding rock or material around the confinement so the high pressure has the destructive effect on its surrounding and surrounding is broken to fragment.

PROPERTIES OF EXPLOSIVES:-

1. Strength: It is the measure of amount of energy given by an explosive on detonation to do the usefull work. The weight strength of any explosive is the ratio of weight of blasting gelatine required to the weight of the given explosive to produce the same strength of energy. The bulk strength denotes the strength compaired with an equal volume of blasting gelatine. Blasting gelatine is taken as base.

2. Velocity of detonation: It is the rate at which the detonation wave passes through the column of explosives. It is important as the energy of detonation increases rapidly with the velocity of detonation. The shock energy does the useful work when the explosive is not confined such as in case of plaster shooting.

3. 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 mine is important, it is advisebale to use a low density explosive, which distributes the energy along the shot hole.

4. Water resistance: Explosives differ widely in resistance to water and moisture penetration. Some explosives deteriorate rapidly under wet conditions, but others are designed o stand water long enough to enable the work to be done. When

should be used. He higher the nitroglycerine content of an explosive, the better its water resistance properties.

5. Sensitivity: An explosive 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 and even over short gaps such as may occur in practice.

6. Fume characteristic: Explosives which are to be used where ventilation is restricted must produced a minimum of harmful gases in the products of detonation. Slurry explosives and AN based explosives are preferable ito the NG based ones.

7. Legal permission: Only permitted explosives of proper type should be used in underground coal mines.

2.2 Classify explosives, state composition, properties and uses of explosives.

Explosives are classified in two types depending upon the speed with which explosive effects is produced.

1. Low explosives. 2. High explosives.

Low explosives:- It is the mechanical mixture of finely ground combusustible substances those are fixed by ignition and have the heaving effect. The common example of this type of explosive is gunpowder. The process of combustion due to ignition of the combustible material is from grain to grain. There is gradual build up of pressure with the gradual increase in the volume or gases produced due to grain to grain combustion. The pressure energy causes heaving effect and rock is broken.

Advantages of low explosives:

1. These type of explosives can be prepared easily and can be safely handled.
2. These category explosives have less shattering effect

substances propagated from particle to particle through whole mass of the explosive

Disadvantages of low explosives:

1. Low explosives have a tendency to absorb humidity in very short period of time so exposure it to humid condition may make it useless/inactive.
2. Due to use of this type of explosive there would be a possibility of fire damp explosion (CH_4 gas explosion) in underground mines.
3. When the low explosives are blasted on quarries it produces high density dust particles, coal dust and floating fire.

Gunpowder:- Gunpowder is a common example of low explosive. It is the contains the following constituents (by weight, approx.)

Charcoal 15%, Sulphur 10%, Potassium Nitrate 75%.

None of the constituents is explosives by itself. Gunpowder is cheap, stable, safe to handle and it does not adversely affect the roof in underground mines as its action has a heaving effect. It is easily manufactured and is available from local supply contractors in many mining localities. It is however, not used on a large scale as it losses its explosive power when damp and it is not as strong as other high explosives. Moreover, during blasting, it produces flame of long, duration and the burning practices are liable to remain in contract with the surrounding atmosphere for some time. For these reasons gunpowder is not used in wet place and in underground coal mines. The explosive is fired by safety fuse.

High explosives:- High explosive is chemical explosive compounds mixed mechanically when detonated undergo instantaneous chemical decomposition and reaction to produce enormous amount of gasses building sudden high pressure in confinements which cause shattering effect. The main constituents of high explosive

chemicals are mixed with other combustible materials. When such mixture is blasted by detonator, the chemical compounds and the combustibles instantaneously undergo chemical decomposition and chain reactions starts.

Advantages of high explosives:

1. As high explosives have high shattering effect, we can get good result and yield during explosion.
2. As it does not produce hanging fire so the permitted type high explosive are used in underground colliery, which reduces the possibility of gas explosion.
3. It is more sensitive than low explosive.

Disadvantages of low explosives:

1. Due to high shattering effect the peripheral constructional area can be affected such as it can develop cracking.
2. As it is more sensitive in nature than low explosive, so a little carelessness it may explode. So it's handling and transporting process should be done with care, otherwise a little bit of jerking, friction may cause explosion.

The differences between the high explosive and low explosive:

HIGH EXPLOSIVE	LOW EXPLOSIVE
1. The chemical explosive compounds are used in high explosives and they are mechanically mixed.	1. It is a mechanical mixture but each component is not explosive in itself.

2. The detonators are required for blasting as blasting is due to impact of shock wave.	2. The blasting is carried by firing the fuse by ignition.
3. There is very high speed decomposition of chemical compounds.	3. There is slow decomposition reaction of components.
4. There is sudden rise of temperature due to flame of detonation and its propagation through explosive.	4. There is gradual rise of temperature as burning continues from grain to grain.
5. Pressure built is sudden as the gases formed due to decomposition are large in volume and sudden.	5. The pressure built up is slow as gases are formed from the grain to grain burning.
6. Due to sudden rise in the pressure he explosive has the shattering effect.	6. Due to gradual rise in pressure, there is heaving action.
7. The velocity of detonation is few kilometers per second.	7. The velocity of propagation of flame is few m/second.
8. It is fragmentation and the dust formation is more.	8. More lumps are formed and dust production is less.
9. It is fired by detonator.	9. It is fired by safety fuse.

IMPORTANT CONSTITUENTS OF HIGH EXPLOSIVES:

Nitroglycerine: It is an only fluid with sp. gr. Of 1.6 and freezing point at 13°C. It is insoluble in water and is very sensitive to explosion by shock of any nature. The sensitivity to shock increases when nitroglycerine freezes. To render it suitable for industrial use, it must either be absorbed by some inert material or be gelatinized. NG based explosives are available in 3 consistencies; gelatinous, semi-gelatinous and powdery. All explosives containing NG have a highly shattering effect and they produce fumes which cause headache after long exposure. Explosives containing NG are liable to freeze when the temperature falls to 8° or less and are then more sensitive to detonation by friction and impact. To avoid this, a low freezing agent, usually dinitro-glycol which is itself as powerful an explosive as NG, is used.

Ammonium nitrate (NH_4NO_3): It is a white hygroscopic salt, very soluble in water and is comparatively very safe to handle. When it is detonated it is, however, a powerful explosives. Though ammonium nitrate is more powerful than the low explosives it is not as powerful as N.G. and it is difficult to denote it by itself with the help of a detonator, but it can be detonated by a booster of high explosive. To use ammonium nitrate as an explosive, it should be mixed with diesel oil, N.G. or T.N.T. Ammonium nitrate is an interesting compound in that it is a high explosive, an oxidizing agent, and a cooling agent at one and the same time. Prilled ammonium nitrate of fertilizer grade mixed with diesel oil is used for large dia. holes in quarries.

Ammonium nitrate does not occur in nature and it is prepared by reacting ammonia gas with nitric acid. When detonated by extreme shock NH_4NO_3 decomposes according to the equation.

$$2NH_4NO_3 = 4H_2O + O_2 + 2N_2 + 346 \text{ kcl/gm.}$$

This property comes into play in the utilization of NH_4NO_3 as an explosive.

Collodion cotton: A reaction between cellulose compounds and nitric acid yields collodion cotton, a high explosive. To render it safe to handle it is gelatine.

T.N.T.: This type of explosives are formed by the reaction between nitric acid & benzene which is a high explosive.

HIGH EXPLOSIVE USED IN MINES:

1. Nitroglycerine: $C_3H_5(NO_3)_3$: It is a oily fluid. It is very sensitive to any shock. It explodes by shock. It reacts on skin. It causes headache. It specific gravity is 1.6. Its detonation temperature is 3150°C. It contains slightly more oxygen than it requires for its explosion. It is used with combustible material and inert material to produce high explosives. All these explosives have very high shattering effect.
2. Dynamite: It is a mixture of nitro glycerin with absorbent earth. This earth is kieselguhr found in fresh water and it contains 95% silica. Dynamite contains nitroglycerine 75% and kieselguhr 25%. This is used for blasting of hardest rocks. Dynamite containing 40% and 60% nitroglycerine are produced the break soft and moderately hard rocks.
3. Blasting Gelatine: Blasting gelatine was discovered by Alfred Nobel in 1875. it is the most powerful of all the explosive. It contains 93 to 95% nitroglycerin and mixed with 5 to 7% collodion cotton. It is used for blasting of hardest of rocks such as quartz and hematite. It is very resistive to action of water. It sweats in hot condition.
4. Gelatine dynamite: In this explosive there is 80% of blasting gelatine. It is mixed with potassium nitrate or sodium nitrate and the wood meal. Wood meal in this explosive is combustible material and the potassium or sodium nitrate is mixed as oxidizing agents. A small quantity of calcium carbonate ($CaCo_3$) is added as stabilizer. It is used in the blasting of medium hard rocks.
5. Special Gelatine and Polar special gelatine: The special gelatine and polar special gelatine are gelatinous explosives. The special gelatine 90%, 80% and 60% are free from noxious gases. These are high density explosive with

quarries, metalliferous mines tunnels, and excavations, sinking of wells, shafts, raises and winzes. Theses are supplied in varying strength to suit blasting in hard to soft rocks. The polar special gelatine is supplied of 60% and 80%. These are the low freezing explosive. They can be used up to (-20°C) temperature. It serves the same purpose as special gelatine.

6. Gelignite: This explosive contains 60% nitroglycerine, 5% collodion cotton, 25% potassium nitrate, 7% wood meal with small p.c. of calcium carbonate and moisture. It is less violent explosive than gelatine explosive. It is an all round explosive used in non-gassy mines and quarry blasting.
7. Opencast Gelignite: (OCG) - It is a gelatinous explosive. It contains nitroglycerine, nitro cotton and ammonium nitrate with small percentage of absorbents. It is a powerful high density explosive. It is water resistive. It is produced with the special requirement for blasting in overburden in open cast mining.
8. Powder explosives: These explosives are non-nitroglycerine base explosives. These are ammonium based explosives. These are now density explosive with relatively high strength. These explosives are affected by water. So the explosives are used in moderately dry conditions.

2.3 Explain PMS and SMS.

PMS (plant mixed slurry): The components required for ANFO and slurry explosives may be mixed at a plant away from the blasting site or at the blasting site itself. In the case of PMS system, the explosive is loaded into special tankers and from these tankers; the slurry is pumped directly into the blast-hole.

SMS (site mixed slurry): Unlike cartridges slurries, pumpable slurries can be tailored to have the appropriate density depending on strata condition. In the case of site mixed slurry system only nonexplosive ingredients are stored at a warehouse and transported to the blasting site in a specially designed pump-truck.

2.4 Define permitted explosive and classify permitted explosive.

PERMITTED EXPLOSIVE: The permitted explosive is the explosive manufactured by such firm and of such type which the Director General of Mines safety specifies in the Official Gazette from time to time.

All explosives create heat and some flame when fired. To avoid explosion of gas or coal dust in an underground coal mine, it is essential that the heat and flame produced by an explosive should be incapable of igniting the gas or coal dust. For this reason explosives for use in underground coal mines are approved by the CMRS and DGMS after certain tests.

CLASSIFICATION OF PERMITTED EXPLOSIVES: Permitted explosives are categorized in the following groups and the group to which a cartridge of explosive belongs is printed on the wrapper of the cartridge.

P1 – Unsheathed explosives, such as Ajax G, Viking G and slurry explosives like Godyne.

P2 – Sheathed explosives.

P3 – Equivalent sheathed explosives (Eq. S) e.g. Unisax G permadyne.

P4 – Explosives approved for special purposes, such as for delay firing, firing in ripping, etc; hitherto known as ultra-safe explosives. These are not produced in India. British examples are; carribel, Nobel's explosive 1235.

P5 – Off-the-solid explosives (for solid blasting) e.g. Soligex, slurry explosive Pentadyne.

USES OF PERMITTED EXPLOSIVES:

1. In gassy mines: Under regulation all mines of coal are declared as gassy. Only permitted explosive is required to be used in all coal mines.
2. When any part of mine or section is on fire, the fire may be sealed or not.
3. In all dry and dusty mines.
4. and all places where there is possibility of liberation of gas due to blasting as in case of fault planes.

GUIDELINES OF PERMITTED EXPLOSIVES:

1. Only permitted explosives approved by D.G.M.S. should be used in underground coal mines. Such explosives are always cap-sensitive.
2. Non permitted explosives can be used in underground metalliferous mines and in the quarry mines of coal as well as metals and also for other surface applications.
3. In watery places, gelatinous and semi-gelatinous explosives should be used. But NG based powdery explosives are not recommended for blasting at watery places.
4. Slurry explosives are water-resistant and they can be used in watery holes but AN based slurry explosives with a specific gravity of one or less should not be used in watery holes.
5. Only explosives with a high velocity of detonation over 2500 m/s, should be used for blasting in hard rocks.

2.4.1 Explain sheathed, equivalent sheathed and ultra safe explosive.

SHEATHED EXPLOSIVES: The sheathed explosives are categorized as P2 explosives in D.G.M.S. notification. These are high explosives. The explosive cartridge is surrounded by sodium bi-carbonate (Na HCO_3). An adhesive coat of sodium bicarbonate is prepared. A coat of 3mm thickness is given around high explosive cartridge except ends. Care is taken that there is uniform and continous coat without any gap or crack. When such cartridge is formed, it is wrapped in waxed paper for the use. Its diameter is always more than normal cartridge. This explosive is more safe. It can be used in mines of any degree of gassiness. This explosive is not manufactured in India.

ADVANTAGES SHEATHED EXPLOSIVES:

1. This explosive is very safe.
2. It is safe even in blasting of hole where gas is coming through crack.
3. It is safe even hole is blown out.
4. Na HCO_3 absorbs heat during decomposition.
5. The sheathing material has cooling effect on flame.
6. Co_2 formed due to decomposition form a blanketing cover around the flame of blasting.
7. Sensitivity if explosive is not affected as sheathing is around the cartridge of explosive.
8. Efficiency of explosive is unchanged
9. Less noxious gases are formed.
10. Percentage of dumpy coal is more and dust formation is less.
11. The weight of sheathing is not included in the explosive.

DISADVANTAGES SHEATHED EXPLOSIVES:

1. Diameter of cartridge is more so special drilling is required.
2. Cost of explosive is more.

4. The sheathing effect is lost if the sheathing is cracked.

PRECAUTIONS OF SHEATHED EXPLOSIVES:

1. Do not roll the explosive cartridge.
2. Do not open the end of cartridge to insert the detonator. Always use pricker.
3. Do not bump or drop the explosive from height. Any crack developed in the sheatheing will be the flame to come in direct contact of atmosphere surround will be the flame to come in direct contact of atmosphere surround it without blanketing and the purpose of sheathing is lost.

EQUIVALENT SHEATHED EXPLOSIVES: These are P3 types of permitted explosive. In this type of explosive inert material is directly mixed with high explosive. In this explosive NaCl and Ammonium nitrate $NH_4\ NO_3$ or $NH_4\ Cl + NaNO_3$ are intimately mixed. These explosives are as safe as sheathed explosives. The permitted charge of explosive is 1020gm. The heat produced by explosive is partly consumed by the cooling agents for their decomposition. Thus the temperature developed by explosive is lowered by cooling agents. The explosive is thus safe for use in gassy mine.

ULTRA SAFE EXPLOSIVES: These explosives are P4 type of explosives. These explosives are safer than sheathed explosives. These explosive contain agents, and combustible matter. In this type of explosive fine powder of NaCl and fine powder of nitro chalk are used in Nobel No.1235. This is not produced in India. It can be used in highly gassy mines.

2.5 State composition, constructional features and use of safety fuse, detonating fuse, detonating relay, igniter cord, nonel, raydet.

SAETY FUSE: A safety fuse which looks like a cord consists of a core of fine grained gunpowder wrapped with layers of a tape or textile yarn and waterproof wrapped with layers of a tape or textile yarn and waterproof coating. The burning speed is usually 100 to 120 sec/metre. ICL manufacturers a range of safety fuses to suit various conditions, e.g., Double Bull brand for dry conditions, Blue Sump for damp conditions, OCPS (orange coloured plastic sheathed) and Blue Plastic for wet and very rugged condition. IDL also manufactures safety fuse (yellow). When one end of the fuse is ignited, it carries the flame at a uniform rate to ignite gun powder or to detonate an ordinary detonator which is turn can detonate a high explosive.

These fuses are supplied in coils of different brands after testing after testing for its high quality and satisfactory performance test of each batch.

Type of fuse	Condition for use	Rate of burning of fuse	
Bull Brand Blue Brand W.C.P.S./OCPS Blue Plastic fuse	Dry condition Damp condition Wet and damp, rugged conditions. -do-	110 to 130 seconds/metre. 100 to 120 seconds/metre 100 to 120 seconds/metre 100 to 120 seconds/metre	The fuse burns due to direct application of fire. The fire is carried up to detonator when fitted.

DETONATING FUSE: For shallow depths, say less than 3m, and for small number of

fuse or in the case of elec. detonator, by an exploder. For a large no. of holes blasted at a time in mechanized quarries and in U/G coal mines electric detonator are used. A deep hole in a quarry needs a long length of detonator leads and to avoid this it is common to use a detonating fuse like cordtex (trade name of ICL. The fuse consists of a core of PETN enclosed in a tape which is wrapped with cloth. The fuse is then completely enclosed in a tubular cover of plastic material which is white for Cordtex and orange for Geocord detonating fuse (ICI). The detonating fuse looks like a plastic cord; its external dia, is about 5mm and weight about 20g per metre length. It has a velocity of detonation of 6500 m/sec, and it is practically instantaneous in its action

A large number of shots connected with detonating fuse can be blasted by a single detonator. A detonating the fuse through the plastic cover. Water may however penetrate into the core through the cut ends which can be guarded against by sealing them with tape or water-proofing compound.

A detonating fuse is often used for demolition operations.

DETONATING RELAYS: In opencast working, detonating relays using detonating fuse for initiation provide a non electric delay firing system. This method avoids the electrical connections which are required when using delay detonators. A detonating relay is essentially an assembly an assembly of two open ended delay detonators coupled together with flexible neoprene tubing in an aluminum sleeve suitable for crimping into a detonating fuse.

Inside the detonating relay, the construction is symmetrical with the delay element at either end so that the detonation wave may pass in either direction. The delay interval for each detonating relay varies from 15-45 milliseconds. In sue, the

main or branch line of detonating fuse is cut at the point where a delay is required, and the detonating relay is then crimped between the two cut ends of the line. By judicious selection of the points at which the detonating relays are inserted, any delay firing sequence can be arranged. Being non electric in nature, detonating relays are insensitive to stray current and static electric.

NONEL: Nonel system of blasting is developed by Nobel AB of Sweeden. Primer of explosive along with Nonel detonators are inserted into a blast hole. Then nonel tubes are bunched when initiated the shock wave passes through the tube, which are arranged for the convenience of the connection to the main blasting system. After passing of shock wave through the tube the reacting element maintain in the shock wave at a rate of 2000 m. per second which is sufficient to initiate the delay element or prime charge in the detonator. Since this is in a tube form, so no blasting occur only it acts as signal conductor.

Nonel means non-electric detonator. The flexible plastic tube has 3 mm external and 1.5 mm internal diam. The tubes are available in pre-cut lengths. One end of the tube is fitted with a non-electric delay detonator which is crimped to it in the factory while the other end is sealed. The end having detonator is lowered down into the blast hole while the sealed end projects outside the hole. The sealed end is initiated by a detonator or detonating cord.

The advantage of the Nonel system lies in its extreme resistance to accidental initiation by static electricity, stray current, radio transmission, flame, friction and impact. It is also immune to misfires caused by current leakage in conductive ore bodies and eliminates the need for complicated electrical circuit testing and shot-firing equipment.

RAYDET: Raydet is a non-electric initiating device of combining the advantage of electric detonator & detonating cord. It is a plastic tube containing small amount of

crimped at one end of the ray tube and the other end is sealed.

When it is initiated a lower order shock wave passes through the ray tube and helps the detonator to be exploding. The ray tube can be initiated by detonator or detonating fuse.

A tag indicates the delay number and a tape fastening with the tube indicates the length of the tube. Length of the tube varies from 3m to 45m. the delays are from no. 0 delay to no. 15 delay; No. 0 delay is instantaneous No. 1 delay is 50 ms and No. 15 delay is 625 ms.

The sealed end of the raydet should not be cut and two raydet should not be combined, because one raydet cannot initiate the other.

2.5.1 Describe different types of detonators and uses, state advantage of delay detonators.

DETONATOR: Detonator is a media to explode the high explosive. It consists of a small tube of aluminums or cooper containing a small amount of high explosive of special type. When these detonators are fired by fuse or electric circuit, it produces a very high velocity of detonation which is capable to produce a very strong shattering effect in surrounding high explosive in which the detonator is placed. Due to this shattering effect the high explosive is exploded or fire.

Detonators are of the following types:

1. Plain detonators (non electric type)
2. Electric type detonator

   (a) Low tension (L/T) detonators, and (b) High tension (H/T) detonators
3. Delay detonators

   (a) Long delay detonators, and (b) Short delay detonators.

1. PLAIN DETONATORS: It contains a aluminium tube of 6 mm diameter and 32 mm length. It is made out of a 0.3 mm thin section aluminium plate and it is closed at one end. The tube contains 0.25 gm of base charge. The base charge is the main charge of tetryl. This acts as a main detonating charge. The base charge is covered by priming charge on top. The prime charge contain the mixture of lead azide and lead styphnate with small % of aluminium powder.

2. ELECTRIC TYPE DETONATORS: Electric detonators are same as that of plain detonator when the prime charge & base charge is concerned, but it is different from plain detonator by the process of initiation. These are fired by passage of electric current through the detonator. They are further subdivided as :

(a) Low tension detonators, and

(b) High tension detonators (not generally used in mining)

In low tension detonators there are two brass foils of unequal length. Brass foil is soldered to leading wire. Two bass foils are separated by hard board. The other end of the brass foils is connected by a bridge of thin Nickel chromium wire.

In high tension detonators there are two brass foils of equal length. These foils are soldered to two leading wires ends. These foils are separated by hard card board. The open ends of brass foils are dipped in the flashing mixture.

COMPARISON OF LOW TENSION AND HIGH TENSION DETONATORS:

Low tension detonators	High tension detonators
1. It is used for blasting of high explosive. 2. The detonator tube may be either aluminium or cooper. 3. It has base charge of PETN or tetryl.	1. It is used for blasting of high explosive. 2. The detonator tube may be either aluminium or cooper. 3. It has base charge of PETN or tetryl.

5. It is electric detonator.	5. It is electric detonator.

DIFFERENCE OF LOW TENSION AND HIGH TENSION DETONATORS

Low tension detonators	High tension detonators
1. Brass foils used are of unequal length.	1. Brass foils used are of equal length.
2. Ni-Cr wire bridge is used.	2. Graphite powder act as semi conductor.
3. The flashing mixture used in this case contain LMNR, Potassium chlorate, charcoal and nitro cellulose.	3. The flashing mixture used contains LMNR, potassium chlorate, char coal, nitro cellulose with copper acetylide and graphite powder.
4. The intenal resistance of detonators is equal.	4. The internal resistance of detonators is not equal.
5. The internal resistance is 1.25 ohms and including 30 m blasting cable the resistance is 7.0 ohms.	5. The internal resistance is 1500 to 30000 ohms. The resistance of the blasting cable is comparatively negligible.
6. The current required for blasting is 0.25 amp.	6. The current required for blasting is 0.025 amp.
7. The voltage require for blasting in minimum 3.5 volts but generally 5 volts is used.	7. The voltage required for blasting is 50 volts.
8. The continuity of the circuit can be tested safely.	8. The continuity of the circuit can be tested.

	other leading wire is red.
10. The extra length of the blasting cable affect resistance of the electrical circuit.	10. The extra length of the blasting cable has negligible affect in the resistance of circuit.
11. These detonators can be used for simultaneous blasting with series connection.	11. These simultaneous blasting with these detonators is not possible.
12. The defective detonators or fault in circuit can be tested before blasting.	12. The defective detonators and fault the circuit cannot be tested perior to blasting.
13. The detonators are connected in series.	13. The detonators are connected in parallel.

DELAY DETONATORS: Concerning to the composition and appearance it is as like as low tension detonators. As it coming under low tension detonators.

In addition to electric detonator a delay element is filled within a brass sleeve between fuse head and prime charge.

The special composition burns at specific rate and the delay can be obtained by varying the length. Thus the delay period of a detonator can be increased by increasing the thickness of delay element over ASA. So the delay detonator is longer, than a delay detonator containing less thickness of delay element of special composition.

The delay action detonators used are of two types.

1. Half second delay detonators which are also known as long delay detonators (Antimony and potassium permanganate based composition) and,

2. Millisecond delay detonators which are known as short delay detonators (special composition of red lead & silicon).

Half second delay are available in a range from no. 0 to no. 10. The no. 0

has the delay period of 5 seconds.

Short delay detonators have faster burning delay, beyond no. 4 delay the delay interval between successive detonator are 50 millisecond from 4 to 12 and beyond 12 it will be 10ms up to 15ms.

Some Important provision regarding delay detonators are:

(i) It should not be used in gassy mines where the permitted explosives are to be used.

(ii) The ordinary type detonator & delay detonators should not be kept on a same case.

(ii) Loading wires should be of sufficient length without any extra wires.

Delay detonators are mainly used in multi raw blasting in a definite sequence. The plain electric detonators should not be used in place of delay detonators.

ADVANTAGES OF DELAY DETONATORS:

1. The efficiency of blasting is more.
2. The explosive required is less.
3. Better fragmentation is obtained.
4. Additional free face is made available for successive blasting of holes.
5. The time required for blasting of large number of holes is reduced to minimum.
6. The ground vibrations are less due to controlled blasting by millisecond delay detonators.
7. The risk to damage to structures and building are less.
8. The number of stoppages for blasting are minimized.
9. The number of frequent running for taking the shelter by workers and others are less or minimum.

10. Large number of hole can be blasted at one time.

11. The number of blasting sounds can be counted.

DISADVANTAGES OF DELAY DETONATORS:

In case of delay blasting the successive delay number will be blasted in the dust produced by the previous delay number. Moreover the successive delay number will be blasted in the atmosphere in which the gas is given out by the previous delay number. Hence the use of delay detonators in coal mine was totally restricted. But with the improve in the design of detonators and more safe explosive the use of carrick type of delay detonators is permitted with P5 type of explosives which are used for solid blasting. In carrick detonators copper tubes are used with 3m long leading wires. This series of detonators have been number from 0 to 15. in these cases the delay detonator of 0 to 4 number have delay period, of 25 milliseconds more while the detonators of 5 to 12 number delay interval varies by 50 milliseconds and from 12 to 15 the delay interval varies by 70 milliseconds. The ordinary electric detonators are not used in place of zero number detonators. The ordinary electric detonators will not blast instantaneously and together when the electric current is sent through the circuit. There is nil delay period between the supply of electric current and detonation of the detonator. The delay detonators are alwys connected in series. Same number of delay detonator will blast at one and the same time while lower number of delay detonators will blast first followed by next higher number delay. The sequence of blasting is 0, 1, 2, 3, 4, 5 etc.

2.6 State different types of exploder its construction and safety features, circuit tester.

EXPLODER: Different types of high explosives are used for blasting in mines. These high explosives are initiated by the detonation wave of detonator when it is blasted

are invariably. Electric blasting is more safe and quick as number of holes can be blasted at one time from a safe distance. The special type of apparatus used to supply electric current for blasting of electric detonators is called exploder. The exploders are the small portable apparatus and these apparatus are capable to generate the required current of specific voltages and amperes.

The types of exploders used in mines are :

1. Magneto exploder
2. Battery exploder
3. Dynamo exploder and
4. Transitorised exploder

Magneto Exploder: The magneto exploder consists essentially of a permanaent steel magnet between the poles of which revolves an armature rotated through gearing by rotary handle or by a rack and pinion. The value of the voltage depends upon the speed at which the armature revolves and the flux created by the magnes. A low tension exploder gives a voltage of ablut 15 volts. A.H.T. exploder gives about 125 volts. The mangneto exploder fires only 1 or 2 shots at a time with single shot exploder and upto 6 shots in series with a 6-shot exploder.

The exploder for U/G coal mines should be intrinsically safe. The armature is actuated by a special twist action detachable key which should always be with the shot firer.

Battery Exploder: In this type of exploders four or six dry primary cells are used. These dry primary cells are connected in series. The e.m.f. of each primary cell is 1.5 volt. The exploder has a detachable key. When this is fitted and rotated through

half wind, the shaft winds the spring against the spring action. The shaft is provided with governor contact. The governor contact can make or break electric circuit. One terminal of series connection of cell is connected to terminal point T1 and other terminal of series connect is connected to T2 terminal point through a contact plug. T1 and T2 terminals are outside to connect the blasting cable. The contact plug is operated by governor contact. After half the wind of key when it is released its shaft is rotated at fast speed by the unwinding spring. Due to high speed rotation of shaft the governor contact flies away and plug contact is made. At this time the current is supplied to terminal point T1 and T2 so the current will flow through the detonators and will be blasted.

Dynamo Exploder: A small strong dynamo contains thin Cu wire armature winding. This armature winding is rotated in the earth magnetic field at high speed to generate the strong induced electric current. This current is used for the blasting purposes. The principle of working of dynamo is nearly similar to the magneto type of exploder. These exploders are also provided with condenser circuit with indicator bulb and push button switch. When the armature windings are rotated through rack and pinion at high speed it generates the required current and voltage and the condenser gets charged. When the condenser is fully charged the indicator bulbs starts glowing. The further rotation of armature is stopped after removing the handle or key. The push button is provided on the exploder and T1 and T2 contact point. The T1 and T2 contact points are connected to blasting cabling. When the push button is pressed the condenser gets discharged and electric current flows through the blasting cable. So the detonators connected in the circuit will be blasted.

Transitorised Exploder: In this type of exploder the ordinary cell of battery are replaced by transitorised electronic cells. It is provided by push bottom and its electronic circuit is made intrinsically safe. The electronic circuit is connected to two

small in size and can be carried in the pocket by the shot firer. When the holes are to be blasted, the connections of the holes will be made at the face by the shot firer. The circuit of blast holes will be connected to the blasting cable. The blasting cable will be laid up to the safe place of shelter after giving warning to the workers to take proper shelter. At the shelter the transitorised electronic exploder is taken out form the pocket. The blasting cable is connected to the terminals T1 and T2. After giving warning the push button of exploder is pressed. The holes connected in the circuit will be blasted. The precautions taken in this case of blasting is same.But in this case, the shot firer carries the exploder with him as it is of tiny size that can be carried in pocket.

ACCESSORIES:

1. CIRCUIT TESTER:- Circuit tester or blastemeter is used to check the continuity of circuit. Prior any attempt for blasting the continuity of circuit to avoid any open or short circuit.

During testing there should be limited current in the circuit, and testing is made of a safer distance from the blasting site.

The electric circuit tester is available in two ranges..

i. 0-100 (ohm) for U/G use

ii. 0-100 (ohm) for other application

2. CRIMPER:- A Crimper is made up of pliers used to crimp or press the soft end of the detonating fuse being inserted into a safety fuse so that it will not come out.

3. SHOT FIRING CABLE:- During electric shot firing, shot firing-cable of longer length is used to detonate the detonator or to fire a shot at a safer distance. The shot firing cables are twin care and are insulated to with stand 250 v.

Other accessories include

i. A wooden steaming rod to steam the blast hole.

ii. A wooden dolly weighted with brass & lead for internal structure of blast hole.

iii. A crimper usually made up of brass, aluminium, wood used to crimp the cartridge to insert the detonating fuse, safety fuse etc.

3.0 BLASTING PRACTICES IN MINES

3.1 Describe preparation of charge:

The charge for blasting in a hole consists of one or more cartridges. It is desirable to have the least number of separate cartridges as far as possible, commensurate with the work to be done.

One of the cartridges should have a detonator inserted into it. Such cartridge, equipped with a detonator, is called a “primer cartridge”.

If an electrical detonator is used to prepare in primer cartridge, open the cartridge at one end, make hole with a pricker of brass or wood, insert the detonator until it is completely buried in the explosive, put back the flap of the cartridge and hitch the leading wires around the cartridge to prevent the detonator being withdrawn accidentally during charging. Permitted slurry explosive can be primed from the sides by pricking a hole into it.

3.2 State procedure of firing shots.

The whole procedure which the sg\hot firer has to follow to fire shots using electric detonators, is outlined below…..

1. Test shot holes for breaks. If a crack is found, the hole shall not be charged.
2. Test for gas from the hole and within 8 m of the hole.
3. See that the shot hole is 150 mm less than the depth of the cut, if a coal

4. Mark direction of the shot hole on the roof or side where practicable.
5. Charge the hole with explosive; insert the primer last of all. Don't force a primed cartridge into a shot hole of small size.
6. Stem the hole, first lightly and then hard, up to its mouth.
7. Spray stone dust or water within 18 m of the area.
8. Warn the workers to clear up and post helper at suitable places 27 m away in approach roads to prevent workers inadvertently entering the area.
9. Lay out the shot firing cable.
10. Test again for gas within 18 m.
11. Couple the firing cable to detonator wires. If more than one shot is to be fired, all connection of detonator leads should be in series.
12. Take shelter.
13. Couple shot firing cable ends to the exploder.
14. Shout a warning again; ensures that workers have taken shelter, and fire the shots by a sharp twist of the exploder key. If the charge does not explode, try again with a sharp twist of the exploder key.
15. Allow the fumes and gases to clear.
16. Return to the shot hole, examine the roof, sides and timber supports and shout "all clear" for the workers to return to their work if the place is safe. Otherwise, have it dressed by dressers, and supported by timber man before workers enter it.

At the end of the shift the shot firer should write a report about the quantity of explosives blasted and the place of blasting.

Stemming materials: Improper confinement of stemming can cause wastage of explosive energy, blown of boulders and fly rock. The best stemming material is sand. However generally drill gumming are used as stemming materials.

Stemming length should be 0.7 to 01Lm time the burden, optimum stemming reduces the explosive amount used, formation of boulders, increases blasting efficiency. Angular type pebbles are suitable for stemming as they wedge themselves when the gases pushes them with high pressure of ring explosion.

Cushion blasting: When the air space is formed between the charge of explosive and stemming material of hole, such hole blasting is known as cushion blasting.

Water infusion blasting: When the blasting hole is treated with high pressure water and blasting is carried of water filled hole, such blasting of hole is known as water infusion blasting.

Direct initiation: When the dealing end of detonator is facing the charge of explosive in the hole, the blasting of such a hole is known as direct initiation.

Indirect initiation: When the dealing end of detonator is facing the back of hole, the blasting of such a hole is known as indirect initiation.

3.3 Determine blasting efficiency: Blasting efficiency of an explosive can be defined as the capacity of an unit weight of the explosive to product maximum output with producing small amount of fires an high degree of safety.

Blasting efficiency will depends upon strength of mineral, watery condition, presence of folds & faults.

Procedure adopted for blasting in coal mines...

2. Test the shot for the presence of crack by crack detector. If crack is detected at the back of hole do not charge the hole.
3. Test the gas up to 18 m from the hole.
4. Measure the hole and see that it is 15 cm less than the machine cut given in the face.
5. Mark the direction of hole on roof or side.
6. Charge the hole with explosive cartridge or cartridges followed by priming cartridge last.
7. Stem the hole with stemming material first lightly and then stemming hard up to the mouth of the hole.
8. Spray water or stone dust on floor, roof and sides up to 18 m radius of hole.
9. Warn the workers and fence the entries from other sides.
10. Layout the shot firer cable up to the face.
11. Test gas for 18 m distance from hole.
12. Connect all the detonators of blasting hole in series.
13. Test the series circuit with the blasting cable of shot firer.
14. Connect the series circuit with the blasting cable of shot firer.
15. Give warning to the workers to take shelter.
16. Take shelter and give warning.
17. Connect the blasting cable to the exploder.
18. Shout and give warning.
19. Fire the holes. If holes are not blasted, try again.
20. When holes are blasted reach the place of blasting. Check the supports. Get the hanging and loose material well dressed. Secure the place by supporting.
21. Give all clear signal to the workers to resume the work.

3.4 Solid Blasting:

3.4.1 Define blasting of solid, state advantages & disadvantages of blasting of solid. Describe different patterns of shot holes.

SOLID BLASTING: In a development of galleries, coal can be blasted without giving an undercut, by using P5 type of explosive, such type of explosives are known as solid blasting or blasting of the solid.

ADVANTAGES OF SOLID BLASTING:

1. It eliminates the use of coal cutter for make an undercut at the face. Again the fitting and controlling of coal cutter is risky and difficult.
2. Skid mounted coal cutter is used by anchor pipes up to 2.2 m height. The roof and floor of the seam is too hard for this purpose. So it can't be used.
3. When working in a seam of curved face it is not possible to use coal cutter.
4. Saving capital expenditure an equiptment, like coal cutting machine, gate & boxes, cables etc.

DISADVANTAGES OF SOLID BLASTING:

1. Chance of blown out shots due to absence of extra face.
2. There is a possibility of ignition in inter connected cracks & breaks by earlier delay shouts by delay blasting.
3. In absence of cutting machine the consumption of explosive will be high.

DRILLING PATTERNS / SHOT HOLES PATTERN:

Drilling patterns, also called shot-hole patterns, are named after the type of cut holes used and the principal patterns are :

(1) Pyramid cut or cone cut (2) Wedge cut (3) Drage cut

(4) Fan cut (5) Burn cut (6) Coromant cut, and (7) Ring drilling.

1. Pyramid cut or cone cut: Pyramid cut consists in drilling holes at corners of square, 0.7 to 1 m sides, almost to meet at a point at the back of the round. In a modified design known as cone cut, holes are drilled forming corners of a polygon with a centre holes, all nearly meeting at a point at the back of the cut. The depth of pyramid cit is generally restricted to 50% to 60% of the width of the drift.
2. Wedge cut: Wedge cut takes the form in which 2 to 4 pairs of holes are drilled to form a wedge, each pair starting from two sides of the drift centre and inclined at an angle less than 45° towards the centre almost meeting at the back of the cut along a line.

   Pyramid and wedge cuts, the most commonly used forms, are suitable for uniform, thickly bedded and hard rocks. They consume the least total quantity of explosives, but the depth of pull is restricted by the width of the drift.
3. Drag cut: Drag cut, used for small drifts, 1.8 to 2.4 m wide, consist in drilling holes at an angle to the cleavage so that strata break along the cleavage planes. This pattern, being dependent on the direction of cleavage planes, calls for frequent changes, which are detrimental to systematic work and the pattern is, therefore, not favoured for large excavations.
4. Fan cut: Fan cut, favoured for laminated strata, mostly soft, covers the face with a fan-like pattern. As each shot has to act for itself, charge in each hole is heavy. This cut is not recommended for hard ground.
5. Burn cut: In burn cut, parallel holes at right angles to the face are drilled in a cluster which may take several forms. Some of the holes are left uncharged to give relief to the heavy concentration of explosives in charged holes. This cut

is effective in hard, brittle, homogeneous ground which breaks evenly: but cannot be used in springy plastic ground.

The advantages claimed for this cut are:

1. Drilling time is considerably reduced and supervision in drilling is easier as holes are straight.
2. Depth of pull is dependent of the size of the drift, and
3. The quantity of blasted material is not projected far with a suitable form of the cluster.

6. Coromant cut: Coromant cut is a new type parallel cut hole process consist in drilling a slot at the middle of face, to get more advancement per round in the tunnel. The slot is produced by contiguous drilling of two holes which are left unloaded alongwith 6 cut hole with proper measurement of distances. All the shot holes are drilled by pusher-leg drill machine. The central slot is driven by 20 mm drill rod and with a special drill rod of 57 mm diameter. In coromant cut system two holes are driven each of 57 mm such that they form 8 shape. The central slot is surrounded by 6 cut holes. The central slot is left uncharged to give a free face to the surrounding cut holes, drilled by the help of template. The cut hole no. 1, 2 etc. are initiated by delay detonators.
7. Ring drilling: For some types of stopping operations in metalliferous mines drilling with long holes is practiced. There are 2 types of ring drilling (a) Vertically ring drilling where rings are drilled in vertical planes, radially like a fan to break to a vertical face; applicable in sub-level stoping, (b) Horizontal ring drilling where the holes are fanned out radially in horizontal planes to break to a horizontal face; applicable in shrinkage stoping. The principle is the same as for vertical drilling and blasting. Short delay interval of 25 millisecond is usually employed between holes in each row or ring, starting from the easiest breaking section in the middle and progressing towards the walls.

4.0 Alternative to Explosives:

4.1 State Cardox, Hydrolic coal Burster, Armstrong air breaker, their advantages and disadvantages:

CARDOX: Cardox is the name given for using carbon di-oxide cell. The carbon di-oxide cell consists of three parts (1) Firing Head (2) Liquid CO_2 tube and (3) discharge head. The complete cell is made of stainless steel.

The cardox cell is fitted with the firing head and discharge head. The firing head is carrying heater tube and discharge head is carrying the shear disc during the fitting. The assembly is made on surface. The cardox cell is connected to refilling pump through the valve on the discharge head. The valve is pressure operated and the pump fill the liquid CO_2 tube with the liquid CO_2. when the liquid CO_2 tube is filled with liquid CO_2 the valve is automatically closed and the cardox cell is fully charged. These charged cardox cells are carried on shoulder in the mine for their use to win the coal.

Advantages of Cardox:

1. Large coal produced is more.
2. The dust production is less.
3. There is no ignition of fire damp.
4. Noxious gases are not produced.
5. There is no shattering effect on roof and roof is not damaged due to blasting.
6. Charging of hole with cardox can be made before giving of the cut to the face.

Disadvantages of Cardox.:

1. The blasting cost is high as compared to explosive.

2. Cost of liquid CO_2 plant is high.
3. Transport of cell is troublesome.
4. Blasting in hard coal is not effective.
5. Stock of pair cells is required.
6. Preparation of charge at the face is not possible as the recharging of the cells is on surface.

HYDROLIC COAL BURSTER: In case of hydrolic burster there is a long tube made of stainless steel. The dia of steel tube is 50 mm to 90 mm. there are closely placed tinny pistons or plungers on surface of the tube. One end of the tube is closed and the other end has the tubing to fit with pressure hose pipe. The length of the barrel is 1.0 m. A hole is drilled in the coal face to receive the barrel. The barrel is placed in the hole such that its close end is in the hole. The barrel is tightly fitted in the hole and its tubing is connected to the pressure hose. The pressure hose pipe is connected to the high pressure pump. The pump is operated mechanically or electrically. When pump is operated the pressure is built up by water in the barrel. These pistons exert high pressure on coal. The coal breaks under high pressure exerted by these small pistons.

Advantages of hydrolic coal burster:

1. The method is free from the danger of ignition of gas or coal dust.
2. The dust formation is least.
3. There is no danger of injury due to no flying of coal.
4. There is no formation of noxious nitrous fumes.
5. There is no shatter of roof.
6. The workers are not required to take shelter.
7. Interruption of working is less.
8. The operation is not making any noise.

10. The face supports are not affected due to breaking of coal.

Disadvantages of hydrolic coal burster:

1. There is increase in humidity of mine air.
2. Pumping of water is more.
3. It is not recommended in hot mine.
4. It is not suitable for blasting in hard coal.

ARMSTRONG AIR BREAKER: The Armstrong air breaker is used for blasting in the under ground coal mines. In this case compressed air is used for breaking of coal. The air breaker consists of the following equipments:

1. Air Compressor: The air compressor used with air breaker compresses air at a rate of 570 m^3 per minute. The compressor develops pressure and air is compressed to the pressure of 800 kg. per square meter.
2. Receiver: The air receiver is provided to store the air. The steel cylinder of length 1.4 m and diameter 130 mm is used. This cylinder is provided with safety valve at top. The cylinder is also provided with pressure gauge and it is tested at pressure of 3000 kg. per square meter.
3. Pipe line: The special steel pipe line is provided to make the supply of compressed air from receiver. The pipe line may be from surface receiver to underground or from the receiver at bottom of shaft up to the working. The diameter of pipe is 12.5 mm.
4. Shooting valve: This valve is placed at about 20 m away from the discharge end. It has removable key. This valve is connected to pipe line and air breaker shell to supply the air for charging the shell. The shot firer can charge the shell.

5. Air breaking shell: the steel tube used in the shell is 1.9 m to 2.2 m length. The diameter of the tube is 63 mm and the thickness of shell used is 4 mm. The shell consumes 3600 cc to 4250 cc of air per blast. The shell has weight of 19 kg. to 24 kg. At the end of the shell, it is fitted with shear nut. The shear nut is provided with a pin when the pressure of the air is 500 kg. per square meter. The discharge ports of air are inclined to prevent the ejection of the shell during the discharge.

5.0 MAGAZINE:

The construction of the magazine is made on the principle and specification which are approved by inspector of Explosive. It is required to take following safety provision:

1. The floor area of construction is calculated at 1.5 sq.m.per tonne of explosive up to the capacity of 4500 kg. for nitro compound explosives. This area is calculated at 1.1 m^2 per tonne of explosive when the capacity is more than 4500 kg. for nitro compound explosive.
2. Roof of the construction is made of R.C.C. and it must be leak proof.
3. The floor should not be damp.
4. Magazine is provided with porch.
5. The door of magazine and the windows are constructed of thick steel plate and the inside facing is covered with thick wooden lining. The hinges are made of brass and also lock.
6. Water trough is provided at the entrance of magazine, to wash feet before entry in the magazine.
7. Raised platforms are constructed for storage of explosive boxes in the magazine. The distribution is made at the enrance.
8. The magazine is provided with Z type ventilator in the brick course.
9. there is no electric wiring inside the magazine

11. Separate storage is provided, for detonator when the number of detonator is less than 44000. The detonator storage is located in same building but separate entrance.
12. There must be a strong lightening conductor, all steel doors and windows are connected with lightening conductor.

6.0 SHAFT SINKING:

6.1 Determine shape and size of shaft

Shafts are circular in shape and rectangular shafts are rare in this country, the exceptional cases being some of the shafts in metal mines. A circular shaft is best able to resist heavy side pressure for a given cross-section, offers the least rubbing surface to ventilating air current. It is easy to sink and line with bricks or concrete. The finished diameter of a shaft varies from 4.2 m to 6.7 m.

A rectangular shaft sunk in recent years is the main shaft at Mochia Magra Mines, Zawar, Rajasthan (Hindustan Zinc Limited). It is of 5.2 m x 3.8 m in cross-section, vertical, 321 m deep from the shaft collar with 30 cm thick concrete lining.

Shaft sinking is costly operation. The mining companies pay to the shaft sinking contractors amounts varying from Rs. 50,000/- to Rs. 75,000/- per metre of overall depth of the shaft sunk and this amount includes sinking, lining with concrete, head gear, winding engine, compressors and all the machinery required for sinking and lining up to the final depth. The high cost involved demands much care in selecting the shaft site. It is, therefore, a standard practice to bore a pilot hole at the proposed shaft site to have a core of the rocks. Such hole need not be a the shaft centre, but may be within 50 m radius of the shaft centre and often only one hole would serve for twin shafts. The hole gives an idea of the rocks to encounter during sinking and provides data essential for :

1. confirmation of shaft site.
2. selection of water control methods.
3. estimation of sinking time and costs.
4. design of shaft and permanent lining.

The present practice prefers holes with cores of 100 mm diameter. Such large diameter cores and holes are preferred for reasons of deviation control, good core recovery, satisfactory laboratory strength & permeability tests.

Difference between vertical shaft and inclined shaft:

Vertical Shaft:

1. Drivage is difficult and costly.
2. Needs headgear structures and other machinery for sinking.
3. Obtaining for additional information about the deposit is not possible during shaft sinking.
4. Repair and maintenance is difficult.
5. Continuous material transport right from the face to the surface by belt conveyor is not possible.
6. Minors can not travel up to the surface if the winding engine is stopped either due to break down or if the power is off.
7. During shaft sinking shaft has to be sunk through the country rock.
8. Less safe compare to an incline.
9. Shaft winding and deepening is very difficult and it is a costly operation
10. For the same depth it has a shorter length of drivage.
11. Winding speed is higher.
12. It can be sunk for any deposit whether it is out cropped or not.

Incline Shaft:

2. .Headgear structure is not needed.
3. Additional information's about the deposit can be obtained during drivage of an incline.
4. Repair and maintenance is easy.
5. Continuous material transport right from the face to the surface by belt conveyor is possible if the inclination of the seam is less than 18°.
6. Since it has nothing to do with any winding engine miners can travel easily up to the surface in any occasion.
7. During drivage of incline through coal seam / mineral body the coal mineral can be said in the market.
8. Very safe compare to a vertical shaft.
9. Incline drivage heightening and widening are very easy and cheap.
10. For the safe depth it has a longer length of drivage.
11. Haulage speed is lower compare to the winding speed.
12. Generally in is driven into the out cropped deposit or if the deposit is located in a shallow depth.

Mining : Mining is the process of excavation minerals of economics value from the earths crest for benefit of mankind.

Or

Extraction of mineral economically is called mining.

Types of mining :

1. Open cast Mining
2. Underground Mining (Board & pillar and longwall mining)

Applicability of entries :

1. Hard load & steps – opencast mines.
2. Incline or adit – shallow underground mines.
3. Pit or slight – In case of deep underground mines.

Magazine : where we preserve the explosive temporary walling, made up of wood.

Winding machine for removal of garbage.

Surface arrangement and equipment required during shaft sinking.

1. Steam boilers or diesel engines for winding engine, pumps etc. unless electronic power is available.
2. Winding engines and winder fitted with locked coil ropes.
3. Steel headgear of temporary in nature.
4. Double drum winches' for walling scafford.
5. Air compressor for jack hammer drill.
6. Generator with diesel or steam engine for lighting purposes.
7. Fan nearly 300m^3 per minute capacity.
8. Folding doors to cover the shaft top.
9. Signaling arrangements from pit bottom to pit top and from pit top to winding engine.
10. For disposal of debris, chutes, buckets and tippino & with tramling etc.
11. Shaft center of arrangement.
12. Workshop inclining smithly shop, mortar mill and other usual machines.
13. Lamp room, first aid room, magazine, store office etc.

General method of shaft sinking :

Temporary Lining :

It is necessary to support the sides of the excavation to prevent their collapse.

- Alternatively the temporary lining may be suspended from strong iron spikes embedded on the surface round the periphery of the shaft.
- The temporary lining consists of skeleton rings called crub, hanger, plinks of sal wood and foghtenning wedges.
- The skeleton rings are of mild steel made on segments of 3 min length.

- The first skeleton ring to be inserted is suspended by chains from the steel garden frame.
- The wooden pranks are of sal amlong, 215mm wide and 38mm thick.
- The rings are hung at intervals of about 1.2 to 1.5m.
- Cavities behind the planks are packed with wood.
- Blasting should be avoided in the area where temporary lining is essential.

Permanent Lining :

- When strong rock is reached the excavation is reduced to the finished diameter of the shaft.
- The construction of permanent lining which may be of brick, concrete of sperial steel feebing.
- The brick size may be of 225mm, 115mm & 75mm of length, breath and weight respectively.
- Usual thickness of brick lining varies from 0.4m to 0.6m.
- The leveling is to be done by picks and chisels not by explosives from where the permanent lining has to be commenced.
- Sinking is usually stopped when walling is in progress.
- The bricking curb is made of cast iron.
- As the brick walling proceeds the temporary lining is dismentaled in stages.
- The spaces between the brick lining and the excavation is folled with ash, sand, or loose bricks.
- If water percolates from the strata which has been line.
- The packing allows to percolate.
- This prevents build up of hydro static preserve behind the brick wall.
- The water is then piped down the shaft from the water garlands.
- Jadregred mine have permanent lining of concrete from the surface to the bottom of the shaft.

The Piling System :

- The methods is known as simply piling or sheet piling and is united sinking through loose deposits of sand or alluvium neam the surface upto a depth of 20m.
- Interlocking steel piles 6m to 10m long are used and they are practically water tight.
- Additional length may be available by welding or riveting two or three length of piles.
- At the surface the piles are set up to form a ring then they are hammered down on rotation.
- As the piles descend in the loose ground the latter enclosed by the piles is excavated and cleared up.
- It should be remembered that the bottom ends of the piles are kept sufficiently ahead of the excavation to prevent in reach of water or loose sand.
- When the excavation reaches strong rock permanent lining is constructed.

Cassion method :

This method can be divided into three classes—

1. Sinking Drum process or Open cassion method : This consists of a cylindrical well of brick work 0.3m to 0.4m in is thickness over a ms ring having a steel cutting shoe. The shaft is excavated and the from sinks down gradually by its, own weights. As the drum sinks down further brick is added on the top. Concrete sinking drums also can be used. Care must be taken to see that the drum descends vertically and the additional weight may be placed with this objects over the drum.
2. Forced drop shaft method : This is commonly adopted where the strata consists of alternate tough and loose ground. And also when the drop shaft refreses to sink furthers due to very high skin friction. In these case sinking is

drums. This method can be used for depth upto 60m.

3. Pneumatric Cassion method : This method is adopted when there is a dragger of fround filling up the shaft. In other case where there is considerable mush of water under a small head. Compressed air is led into the chamber formed by means of a partition. 1.8 to 2m above the cutting shoe compressed air keeps back the water and sand. An air lock is moeented on top of the partition as passage for men material. The limit of pressurs of air tkgt/cm^2.

Cementation process :

This process can be used in all cases of shaft sinking. Particularly in any fissured water bearing strata except on coming sand or loose ground. It can be successfully applied in smoking even when the in rush of water is heavy. Treatment of ground around the shaft is carried out to achieve one or more of the following objects.

1. To stabilize the collapsing ground.
2. To reduce the inflow of ground water.
3. To avoid flooding.
4. To prevent sand boiling.

This method consists drilling the hole, around the shaft and injectory the storry on water and cement under high pressure through the hole till there completely scaled.

Freezing method :

This method is used when the sinking is proceeding through an constable or friable strata with heavy in reach of water. In this method the formation of large block of frozen ground in water heaving strata helps to prevent in flow of water into this shafts.

The whole process can be divided into three operations.

1. Drilling holes usually 150 mm dia holes as 2.2 to 3m interval around the shaft. The holes after drifting are to be in red with special trebs and cave should be taken to see

2. Special small tubes are inserted to enable the cold brine soketion to pass through the tubes. Cold brings while circulating in the holes extracts the heat from the surrounding strata. Sinking and lining in the normal way after the formation of ice wall.

3. The last and final operation is removing the ice wall by sending hot brine selection.

Precaution of solid blasting : In general this type of blasting not be permitted in the 3rd degree gassy mines. However horizon mining in drivage of coal laterals, in the working of longwall faces etc, it may be permitted with the following provision.

1. In horizon mining : Solid blasting may be recommended if the coal mineral at least 300-500m^3/m air, depending upon the dimension of the drivage the rate o emission of the gas can be ensured at the face.
2. For long wall face solid blasting may be recommence if in the stable at least 300m^3/m and the face at least 100m3 of air can be ensured.
3. After experiment there was no ignition when the interval between adjacent shots were les than 65 millisec and there were positive possibility of ignition if the interval was more than 100 millisec. Therefore the total delay interval between the first and the last shot in a round should not exceed 100 millisec.
4. Standard of supervision should be satisfactory.
5. The arrangement for treatment of coal dust at and within 90m of the site of blasting should be as per statue and stone dust barrier be kept in position.

Restriction :

1. Not fire more than 25 shots in one around.
2. Strictly adhere to the pattern of shot holes and charge per hole etc.
3. Carry out all statutory inspections and precautions necessary for gassy mines.
4. No explosive other than man incentive short delay detonator shall be used.
5. The estimated period of delay between any two consecutive delay shots shall

6. The distance between two consecutive holes in 0.06 m.
7. For degree1 gassy mines at least 2 m^3 and 3 degree at least 284 m^3 of air inserted.
8. Test gas within a radius 20 m at the place of blasting.
9. The firing cable and exploder is approved type.

Shaft Sinking :

Vertical shaft : An inclined may be driven to enter deposits up to about 30m depth. Such long inclines at step gradient of line 4 or line 3 are common at Kolas gold field and Mosubani mines are known as inclined shaft. In India the term inclined changes to vertical shaft.

Inclined Shaft : An inclined shaft in metal mining practice is rarely in the ore body proper which does have conform angle of dip.

Location of shaft : shaft sinking is a costly operation the arrow of sinking shaft varies from 450000 to Rs 15000 per meter of depth of shaft slink. It include lining with comnete head gear, wind engine, computer and all other material.

Stone Drifting :

Find out direction and gradient of shaft :

1. Where a drift is to be triven to prove the throw of a fault and touch the seam on other side.
2. The drift should be driven not in proposed main haulage road through the fault, between in comanion road.
3. This allows suitable grading of the proposed main haulage road once the fault is proved.
4. The surveyor has to mark permanent reference points by pluge in the roof at the starting point of the drift.
5. The gradient line is marked on the side by red lead 1 m above the 100 m of

6. Pluge are fixed on the grade line after every 3 m or 4.5m.

Drilling :

1. For soft sand stone and 110 v rotary coal drift.
2. Nearly 15 holes may be drilled in a shift of 8 hours.
3. The pullis only 1.2 to 15 m distance.
4. The diamond section drill rod wears very fast.
5. For hard sand stone or similar rock. The same arrangement with eccentric dribits work well brct the drilling is lower.
6. Drilling in hand strata is generally carried out by compressed air operated directionally with mechanical feed.
7. After the alignment and gradient are fixed.
8. The drifting starts with drilling shot holes according to a specified form called drilling pattern.
9. Drilling pattern consist of three on force groups of holes.

Blasting :

All holes are charged and fired simultaneously with the use of milliseconds delay detonators. Generally 100 millisecond delay detonator are used in stone drifting. The dimension of explosive 10-12 kg per meter.

Support : The coal pillar formed during drivage of galleries form the natural support. Props should be avoided as per as practicable in roads having tub movements on gradients as they get dis-lodged by men away or derailed tubes. It is very difficult to carry 10 aded baskets on head for tub loading. Roof bolting or roof striching provides a good alternative for such situation.

Drainage : Drainage if water in the mine is effected by pumps as follows :

1. Face pump : As the face advances the pump at the face also has to advance for this reason the pump usually small of 5 to 15 H.P., 50mm section and delivery pipes with capacity of 250 to 450 min capable of developing only is to 30 m head. Centrifugal pumps are generally used but roto pump have greatly replaced them in recent years. The face sump is of a temporary nature and has a small capacity as the face has to progress easily. The sump sermes one week when the face advances 9m to 12m per week.

2. Stage Pump : The pump discharges water into the sump of semi permanent pump in the out bye side called stage pump. It has to delivers water to the main pump. Small accumulation of water in dip working at the face are failed out by boiling majdoor with the help of buckets. As a stable for boiling majdoor small pumps operated by the coal drift are also available.

3. Mian Pump : Each mine has a mian pump to which all the water of mine is pumped. The delivery range is taken to the surface through a bore hole through the surface.

Transportation :

The common mode of transportation major of our mines is rope haulage, through scraper chain conveyers, belt conveyer and 100 m stines have been introduced in some mines. Direct haulage suits well in this respect for the advancing and rail rope haulage the rise headings. Whom the roadway is 100 m or none then rope haulage is used for level heading. Two tracks one for loads and the other for the empties, are always essential at the loading points at the face. Chain conveyor can be readily kept close to the face within shovellable distance by addition of pam. The scraper chain conveyor may deliver coal in to tubs into a belt conveyor.

Ventilation :

- Drifting is an unproductive and much costlier work than drivage of roads in coal.
- The ventilation is always provided by an auxiliary forcing or exhaust fan.
- A small drift, maximum length 300m can be ventilated by a single fan either fording or exhausting.
- To avoid reciruel of air by the fan of should be placed in the path if the main ventilation air current at least 5 m away from the nearest corner of the drift.
- In long drifts, however a combination of exhaust and forcing fan is preferred fan efficient ventilation removal of fans after blasting.
- The use of diesel engine underground makes trenedow demand on ventilation system.
- 200m3/min of air is the accepted requirement of normal size drifts.
- Exhaust on compressed air operated machines largely help in mines.

Organisation and Supervision :

Foreman – 1

Mining sirder – 1

Timber man – 1

Driller – 1 + 1

Loader – 1 + 1

Blaster – 1

Miscellaneous – 5

Total man power – 16,

Output / man shift = 40/16,

= 2.5m^3

Mechanical method of drifting :

Drivage of galleries by coal cutting machine and coal drifts is a common practice for quick progress of heading, large output & fast development of the are when coal cutting machine are used to\he operation at the face require.

1. giving a cut by the coal cutting machine till.
2. Drilling of shot holes.
3. Charging with explosive and blasting.
4. Dressing of roof and sides to radar then safe.
5. Loading of coal into tubs mine cars.
6. Dressing of sides a roof and floor to make the face ready for the next cut.