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# Application of Stemming Systems and Materials in Underground Excavations – A Critical Review

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**ABSTRACT:** This paper discusses different stemming systems available and as employed in the mining industry and other underground excavations different types of stemming materials like Moist clay, Sand, Sand -Clay Mixture, Fly ash-Clay Mixture in use, PVC ampoules for gassy mines, water ampoules for suppression of dust and most recent like the one stemming plugs and a comparative study of the effect of these stemming systems and materials on blast performance in underground excavations.

**KEYWORDS:** Stemming, Blasting, stemming plugs, underground mine.

## I. INTRODUCTION

In Indian mines, stemming is one of the most neglected design parameter. Some consideration is given to stemming length, but no regard is given to the stemming material and also the particle size of the stemming material. In blasting operations stemming is a key element in the “drill and blast” mining phase. Stemming is the process of filling the empty part of a charge case such as blast hole with an inert material like sand, gravel, or clay etc. to retain the products of the detonation of an explosive charge in an enclosed cavity after charging with the explosive. When the explosive charge is detonated, the stemming locks the expanding gases and keeps the forces within the blast hole until rock begins to break. Friable materials that are inert to the action of an explosion and are sufficiently hard having a high coefficient of internal friction are usually used for stemming.

## II. ROLE OF STEMMING

The methods used to confine the gases within a borehole can influence the amount of useful energy obtained from the explosive charge. Improper confinement not only wastes energy and raises the cost, but also can result in air blast, excessive ground vibration, fly rock and boulders. Stemming enhances fragmentation and rock displacement by reducing premature venting of high pressure explosion gases to atmosphere. Good stemming maintains high gas pressure within blast hole for longer period of time. This reduces energy waste, minimizes air blast and improper fragmentation

The length of the stemming may be only 8- 10 times the diameter of the blast hole when the most effective materials and the most efficient explosive charge arrangements are used. In shaft with gas and dust hazards, the length of the stemming is governed by the Safety Regulations.

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## III. RULES OF THUMB FOR STEMMING

1. (Blasting and Explosives Quick Reference Guide 2010, for an Opencast Excavation)  
These rules provide a first estimate in the absence of any better data.

Blast hole diameter in mm	$\leq 15 \times$ Bench height (BH) in metres
Bench height (BH) in metres	$\geq$ (Blast hole diameter (D) in mm)/15
Burden (B)	$= (25 \text{ to } 40) \times (D)$
Spacing (S)	$= 1.15 \times B$ (This gives an equilateral pattern)
Subdrill	$= (3 \text{ to } 15) \times D$
Charge length (C)	$\geq 20 D$
Burden stiffness ratio	$= BH/B$ : 2 to 3.5 good fragmentation : $> 3.5$ very good fragmentation
<b>Stemming material size</b>	<b><math>= D/10 \text{ to } D/20</math> (Angular material with minimum fines)</b>
<b>Stemming</b>	<b><math>\geq 20 \times D</math> or <math>(0.7 - 1.2) \times B</math></b>

2. The basic purpose of stemming is to confine the explosion pressure in the blast hole. The resistance to explosion pressure is provided by the mass of the stemming and friction.

The mass of the stemming material can be calculated by

$$w = A l p$$

Where	w = mass of the stemming material (kg)
	A = cross-sectional area of the blast hole (m <sup>2</sup> )
	l = length of the stemming column (m)
	p = density of the material (kg/m <sup>3</sup> )

The density of an air and water, being less than the drill cuttings, air or water are not better stemming material than the drill cuttings. Frictional forces can be increased by increasing the friction between blast hole wall and stemming and by means of interlocking effect between the particles.

The cross-sectional area of a blast hole being the same, the forces due to weight can be increased by increasing the length of stemming column. If the stemming length is inadequate, the explosive gases will vent prematurely, reducing blast hole pressure and resulting in poor displacement and a tight muck pile. It will also result in fly rock and air overpressure. Longer stemming length gives good confinement but it may lead to poor fragmentation from the stemming region.

3. The stemming length is calculated in terms of burden (Atlas Powder Company, 1987, Konya and Wallei, 1990, Ash, 1990, Poisson et al, 1994, Dick et al, 1986, ICI, 1993). The stemming was found to be equal to 0.7 to 1.2 times the burden (Adhikari et al, 1990). This is also applicable for rocks which are highly jointed, and the natural blocks are smaller than the maximum allowable fragment size. In hard rock, stemming length greater than 1.0 times the burden may cause fragmentation problem from the stemming region. Unless the stemming is maintained as 1.0 to 1.2 times the burden, fly rock is difficult to control. In such cases, stemming efficiency can be enhanced using suitable stemming material or using blast control plugs.

4. The stemming length can be evaluated easily using a high-resolution video camera unlike high speed photography. The ejection velocity cannot be calculated from video records but it has been found to be a simple and effective tool for evaluating the stemming performance. Worsey(1990) studied the effect of stemming on burden movement by using high speed videography. His results suggest that the burden rock movement is inversely proportional to the stemming ejection velocity. The results of his tests showed that the burden velocity was reduced by a factor of three when stemming performed poorly. Armstrong et al (1993) studied the effect of confinement due to stemming on the

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fragmentation and rock movement in model scale experiments. Their results showed that the degree of fragmentation and rock movement improved with the increase in stemming retention.

5. Several kinds of material have been experimented abroad. Water, mud, soil, wet clay and drill cuttings. Drilling dust is easily ejected. On the other hand, dry angular material under the effect of the impulsive gas pressure tends to form a compaction arch which locks into the wall of a blast hole, thus increases its resistance to ejection. Stemming materials, ranked in the order from the least efficient to most efficient are air, water, wet drill cuttings, wet sand, paper cartridge of rock dust, clay dummies, wet crushed stone, dry drill cuttings, dry sand, dry crusher run stone, dry screened stone (Lippmcott, 1992). In water filled holes, gravel and crushed rock quickly settle to form a plug of stemming. The behaviour of drill cuttings can be quite different. They are converted to a sludge which has little to offer, other than its own mass, in opposing explosion gas pressure.

6. Proper particle size of the stemming material is also important when the stemming length is short. Materials containing fine and coarse particles are not suitable for stemming. Fine particles are easily ejected, and coarse particles have a tendency to bridge the hole and can also damage initiating devices. The optimum particle size of the stemming material is 0.05-0.08 times the hole diameter (Konya and Wallei, 1990,ICI, 1993).

7. Worsley and Nixon (1988) developed and patented a mechanical stemming aid for efficient stemming. They have shown substantial reductions in stemming ejection velocity or ejection elimination whilst reducing the stemming up to 35% over conventional practices. Eloranta (1994) evaluated stemming performance in 406 mm diameter blast holes with different sizes of stemming materials, concrete plugs, and decking. His results showed that concrete plugs in conjunction with coarse stemming reduced stemming ejection velocities by 40%. Blast control plugs are now commercially available. It is reported that these plugs significantly improve blasting efficiency while also eliminating most fly rock and greatly reducing air overpressure and dust (JEE, 1996).

## IV. TYPES OF MATERIALS COMMONLY USED AS STEMMING IN UNDERGROUND EXCAVATIONS.

The different stemming materials used in different cases are explained below

1. Moist clay
2. Sand
3. Sand-Clay mixture
4. Fly ash-clay mixture
5. PVC Ampoules
6. Water or Gel filled ampoules and
7. Stem Plugs

### 1. Moist clay

This forms the most popular stemming material because of following advantages;

- It is cheap and available easily.
- It needs no preparation before taking into underground sites.
- It is easily moulded and is incombustible in nature.
- When moistened, it retains the same for a considerable time.

Holes stemmed with two or more clay type stemming cartridges showed no venting and delivered the best blasting results. But the various researchers and blasting principle have found that clay stemming is liable to be ejected in mass by the explosive charge and thus it fails to fulfill its intended purpose.

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Fig 1.0 Clay stemming material



Fig. 2.0 Sand stemming material

## 2. Sand

Ritson and Stafford (1937) found that the sand forms the most efficient stemming material and best sand for the purpose is graded in size between 1.5875 mm to 0.254 mm. This will often stick in the hole and become immovable. In wet holes as in sinking pits and inclined holes, sand alone is an effective stemming material. Sand forms a most effective stemming material. But it cannot be inserted in the normal way in horizontal or upwardly inclined holes. This offers a very high resistance to dislodgement.

## 3. Sand-Clay Mixture

This is generally accepted as the most convenient and effective for general use. It is easy to handle as clay alone and offers almost same resistance as sand alone. The mixture should consist of 3 parts of coarse sand, brick dust or ground clinker to one part of good quality surface clay, together with about 5% calcium chloride to keep it moist. Water should be added to make a stiff paste, not too wet, (say up to 10% water) which will neither flatten nor break-up when a cartridge of stemming is dropped from a height of 1.2m.

## 4. Fly ash-Clay Mixture

A mixture of fly ash – red clay can be used effectively in underground coal mines for stemming, because fly ash is readily available in coal mines so this mixture represents a cost effective or economically cheap stemming material. In Singereni Collieries this mixture in the ratio of 30: 70 ( Fly ash : red clay) has been using effectively in all underground coal mines.



Fig 3.0 Fly ash- Red clay stemming material

## 5. PVC Ampoule

They are stemming materials prepared specifically for use in underground coal mines that are classified as degree II and III gassy mines. Their use significantly contributes to the safety by way of;

- Reducing the risk of methane ignition or coal dust explosion.
- Minimum generation of dust and fumes from blasting.
- Lowers down the degree of fragments.
- More efficient mode of stemming.
- Better powder factor and cost effectiveness.

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### 6. Water or Gel filled ampule

Water or gel filled ampoules (96% water mixed with chemical gelly and bactericide agents) have been reported to be used. Below mentioned results were obtained in general.

- Sealing of the blasthole effectively
- Quenching/cooling the flame of explosion and
- Suppression of dust and also to absorb the fumes.
- Better and uniform fragmentation and much lower degree of projection of fragmented material

It is found to be a very efficient stemming system by way of reduced explosive charge per tonne of coal production and hence very cost effective. The gel filled ampoule with water and organic substances and sealed under factory conditions, has flame resistant non-abrasive cylindrical sheath. Water ampoules consisting flame resistant non-abrasive cylindrical sheath (PVC), around 0.35 to 0.4 m long, are generally self-sealing types and water may be filled on the surface or in the underground. Sometimes cylindrical PVC bags of 30 mm dia. (approx.) filled with water after making a knot at the empty end are also used as stemming material. During charging a shot hole, firstly conventional stemming material made of clay and sand is inserted into the hole, then explosive cartridge and followed by one or two water/gel filled ampoules or water filled PVC bags are inserted. Finally, the mouth of the hole is stemmed with the conventional sand gel filled stemming, the risk of coal dust/fire damp explosion is reduced, thereby improving blasting efficiency due to clay stemming by a minimum length of 0.35 to 0.4 m. With the use of water/ cushioning effect.

### 7. Stemming Plugs

Stemming, Stem, Stem-ming meaning to stop or hold back by or as if by damming; stanch. To plug or tamp (a blast hole, for example). Some of the applications are Geophysical, oil well, exploration drilling etc. Reports indicate that the best results from drilling and blasting procedures have been obtained as visible from post-blast muck pile profiles.



Fig 4.0 Stemming plug



Fig 5.0 VariStem Blasting Plugs

#### 7.1 VariStem Blasting Plugs

The VariStem Blasting plugs reduces processing costs, with achievement of up to a 25% increase in fragmentation. Studies also indicated that VariStem can reduce blast patterns by 10% or greater and achieve the same fragmentation resulting in major savings in drilling and explosive costs. Thus "a very low cost" VariStem is the most effective means of reducing costs of blasting and onward processing.

The other benefits that can be cited are fracturing and breakage of cap rock, reductions in Fly rock, Air Blast, Stemming Ejection, Dust, Noise and Oversized Rock. The field application of these plugs also found that up to 27% reduction in average rock size with more micro-fractures can be obtained.

**Applications:** Open Pit bench blasting, Pre-Split blasting, Choke Blasting, Trench Blasting, Air Decking, Tunneling, Demolition Blasting, Underground Blasting

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### 7.2. Stemtite Stemming Plug

Stem plugs work by creating a blockage effect in the borehole by wedging the stemming material between the borehole wall and the plug. It is a similar situation to plugging up a rifle barrel. Upon detonation the plug is forced upward and moves approximately 1 1/2 to 2 diameter lengths prior to 'locking up'. When the plug seizes in the borehole the blasting energy is contained in the rock where it belongs. There are numerous studies documenting the effect. Fragmentation and Fracturing are INCREASED, while fly rock, air blast, and dust are decreased. Using Stemming Plugs will increase blasting effectiveness by retaining the explosive energy of the blast in the borehole. Stemming Plugs can be used in blasting applications to improve safety by reducing the amount of fly rock, improve fragmentation, expand hole patterns, and reduce air blast and dust. The Plugs, when used in well-designed blasting programs, will increase fragmentation from 20% to 50 % while decreasing Air Blast, Fly Rock, and Dust. Stem Plugs are loaded on top of the explosive and below the stemming material. At detonation the whole column begins to move up and the plug wedges the stemming material against the borehole wall and "locks up". The rapidly expanding gasses are contained in the bore hole leading to a better blast - less wasted energy contributing to fly rock, air blast, etc. This plug in particular is found to result in better fragmentation and improved production. These plugs are available in wide-ranging sizes. Loading Poles are used to position the plugs correctly, dowels are also available.



Fig 6.0 Stemtite stemming plugs

**7.3 Abaq Birdy Plugs:**The "Birdy" is ideal where bulk and cartridge explosives need to be secured mechanically at the collar in small diameter up-holes.

**7.3.1 Birdy 158:** They are designed for small diameter up-holes ranging from 1 5/8" to 2" (40 mm to 50 mm) diameter. Skirt feature permits a better adherence to the borehole walls compared to conventional plugs. Extra-long nose prevents overturning when inserted with loading stick. They are moulded from recycled polyethylene.



Fig 7.0 Birdy 158 Plug



Fig 8.0 Airball

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**7.3.2 Air Ball:** Air Ball help improve fragmentation, obtain a safer final wall, dig easier, eliminate explosive wastage, control void management, blocking off break throughs and protecting holes are just a few applications where Blast Ball™ plugs can be used with excellent results.

The Blast Ball is a unique product with no existing competitive alternative to accomplish what this product is capable of. Some of the other merits are as given below.

- Improved quality at minimal cost
- New improved valving system
- Quick and easy to use
- Robust and durable
- Incredible sealing and load bearing capacity

**7.4 Blast Bags:** An innovative pressure tube built within the bag, helps to keep it cylindrical while lowering to depth inside the blast hole and has an extremely consistent release time. This ensures ease of location in all ground types. The bag is held at the correct depth until the expansion retaining packaging ruptures, under pressure, allowing the bag to rapidly expand and plug the blast hole saving precious operators' time.

1) **3.7.4.1 Chameleon™ — An Innovative Safety Feature**

2) **BLASTBAG EVO™** can now be fitted with a worldwide patented Chameleon™ Safety Indicator. This thermo-chromatic protection indicator uses a series of heat sensitive inks that changes colour with temperature. These colour changes assist to identify and ensure correct storage and safe handling as per the globally harmonized system of classification and labelling of chemicals.

BLASTBAG EVO™ are aerosol inflated blast hole plugs that have been used successfully on surface mining operations worldwide since 1996.

Reliability of the BLASTBAG EVO™ is assured by using the patented total release actuator eliminating issues with actuators not latching in hot climates. When the total release actuator is depressed, the non-flammable gas released from the aerosol canister inflates a gas impervious multi layered bag inside a robust woven outer sleeve.



Fig 9.0 BLASTBAG EVO™



Fig 10.0 Clay Dummies

**7.5 Clay Dummies:** These clay dummies are of the highest quality and come in five different sizes for stemming small diameter holes. Explosive Energy Containment. You can be assured of MAXIMUM compaction and containment of explosive energy with clay stemming. Clay Stemming or "Clay Dummies" have been used in various blasting situations for years.

Used extensively in coal mines, these superior quality blasting dummies are now being used by many small diameter specialty blasters. Selected inert ingredients, which minimize damage to wires and cord, combined with West Virginia Bolivar Fire Clay supplying you with the finest quality containment products available. These carefully selected materials will insure maximum containment of explosive energy.

**7.6 Foam Plugs:** FOAMPLUG™ can be used to stem blast holes, plug breakout holes over old works or in sill-pillars, plug core holes to reduce shot gunning, pack overhand holes to prevent emulsion slippage, and seal pre-drilled holes prior to loading. FOAMPLUG™ has also been used to plug surface drill holes to prevent surface water infiltration.

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Core holes of any diameter or depth can be plugged either on surface or underground. Underground, FOAMPLUG™ can be pumped down a drill string or placed with loading poles at various depths to reduce "shot gunning." FOAMPLUG™ has also been used to consolidate ground in lost circulation zones. Surface core holes can be plugged at any depth above the water line to reduce surface water infiltration or isolate inter-leaving aquifers. Blast holes of any diameter or depth can be plugged with FOAMPLUG™. FOAMPLUG™ can hold up to 3000 pounds of explosives in breakout holes. FOAMPLUG™ can be used to deck around mud seams or voids or to reduce scaled distance for vibration control. Underground, FOAMPLUG™ can be used to retain emulsion in overhand holes or prevent debris infiltration on down holes.

**7.6.1. Horizontal Stemming by FOAMPLUG™:** FOAMPLUG™ is also used to stem horizontal holes underground and in demolition work. In fact, we can increase the pull up to 20% by simply stemming the cut holes in given round of blast. We can also improve overall fragmentation by stemming part or the entire round, including slab rounds. This foam stemming plug is easy to use. It creates an in-place, rigid polyurethane foam plug. This is accomplished by mixing a two-component polyurethane foam inside a plastic bag, which is separated by a bead lock seal. There after pulling the seal will allow the two components to merge. Then next we have to knead together the components for approximately 30 seconds which ensures a thorough mix. Then lower the bag into the hole at the desired depth. Hold in place until foam stem plug is expanded enough to set and then let cure for 10 minutes before stemming.



Fig.11.0 FOAMPLUG™



Fig. 12.0 Max-Blast TM Plugs



Fig. 13.0 Funnel Plugs

**Max Blast:** Max-Blast™ Stemming Plugs are the most effective vinyl plug on the market. The patented "positive seal" accordion design forms a barrier that prevents the explosive gasses from passing up through the stemming material. When the stemming material is undisturbed by rapidly expanding gas it will bridge and lock up in the borehole. Max-Blast™ Plugs employ a simple "Friction Fit" approach. They install in seconds. Simply push the plug into the borehole point down using a charging pole. Max-Blast Stemming Plugs' friction fit in the borehole provides a positive seal for positive results.

**The picture illustrates the Max-Blast method of action:**

Upon detonation the expanding gasses impact the plug and it begins to fold into itself. This process of folding expands the plugs diameter - creating a positive seal in the borehole. You can clearly see in the plug recovered after use that the Max-Blast accordion design folded on the annular rings and prevented the intense explosive energy from passing up through the stemming material.

**7.7 Funnels & Stemming Bags:** Using these funnels and stemming bags, it is found that blasting efficiency can be improved a lot. Here the stemming bags allow you to use drill hole cuttings as a cheap alternative to expensive stemming plug. An extra-large funnel with large throat is ideal for use with powders, granular materials, and viscous liquids. It is made of flexible, non-corroding, non-contaminating, low-density polyethylene. Funnels are an excellent dispensing aid for bulk products.



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**7.7.1 MTI Blast Bag - Solo Plugs:** MTI group manufactures ultra heavy duty blast hole blockers with an inner gas sealed bladder plus an outer sealed bladder and a scuff bag. MTi Group BlastBag™ plugs have transformed their look and simultaneously the market to facilitate the first ever single hand deployable, dual speed BlastBag™. The fully patented latch is the first of its kind and works in all temperatures from extreme heat to extreme cold. No other bag on the market has rivalled the usability and reliability of the NEW Solo BlastBag from the MTi GROUP.



Fig. 14.0 MTi BlastBag™ Plugs

### 7.7.2 Pilgrim Hat Plug

The Hat Plugs™ are available in 1 ¼", 1 5/8", 2", and 3" rock drill diameters. Hat Plugs™, come in a variety of styles and sizes and have an established use world-wide. Pilgrim hat plugs are used in conjunction with stemming and securing cartridges in rising drill holes.



Fig. 15.0 Pilgrim Hat Plugs™

### 7.7.3 Rock Lock

Rock Lock, a high tensile, pliable plastic sphere that reduces and controls the random variables leading to borehole venting and stemming ejection. By improving confinement, Rock Lock improves aggregate fragmentation, enables the explosive to be loaded higher into cap rock and greatly reduces fly rock occurrences for a higher degree of safety. Rock Lock also delivers greater confinement for enhanced vibration control when used in decking applications.

Benefits of using Rock Locks are cited as follows.

- Greater Safety, Improved Fragmentation, Higher Loads for Hard Cap Rock
- Extended Hole Patterns, Blast and Dust Reduction

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Fig. 16.0 Rock Lock



Fig. 17.0 Stemlock Gas Bag

**7.7.4 Stemlock Gas Bag:** It is said that sometimes simplicity is the Best. Stemlock Gas Bags are kind of that which uses a simple chemical process to inflate the plug —no heat, no air compressors, and because Stemlock Gas Bags are sealed at the factory, no fear of leakage. The Stemlock Gas Bag is a self-inflating borehole plug that is used to block or seal a hole at any depth. They are made for 3" to 16" diameter holes. There is no need for an air compressor, for the bags that self inflates chemically. There is no leakage because the Gas Bag is sealed during the manufacturing process. There is no heat produced during inflation and the ingredients are not carcinogenic. Substantial savings of up to 35% in explosives costs can be made by using the Gas Bag for air column blasting techniques.

**Procedure for Field Application of Gas Bag:** Normally these Gas Bags come pre-folded for ease of handling. They are held together by tape or rubber bands. Till the point of use, these tape or rubber bands are not removed because they allow the Gas Bag to inflate properly. Attach a cord to the tag at the top so that the Bag can be lowered to the correct depth in the hole. In the case of the vinegar Gas Bag, squeeze the colored liquid container and pop it. This releases the vinegar onto the sodium bicarbonate. Make sure all the vinegar has drained onto the bicarb pouch then lower in the hole. You have about 40 seconds to get the Bag in place before inflation starts. When the Bag is tight in the hole, remove the cord with a sharp tug.

The aerosol version works by locking down the activator cap on top of the can. Push hard enough to make sure the valve tab is locked down. This releases a colored liquid for about 40 seconds of delay time before inflation starts. Again, give the cord a sharp tug to retrieve it once the Bag is held tight in the hole.

### V. COMPARATIVE ANALYSIS OF STEMMING MATERIALS

Based on the above mentioned different stemming material and with different researches described a comparative Analysis can be drawn as follows by taking some of the applicable parameters such as type of Blast holes whether the holes are in Dip Gallery, Rise Gallery or Level Gallery etc. and also efficiency of each stemming system on Fragmentation of the blasted coal, Noise of the Blast, Ground Vibrations etc. in the table given below

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Applicable Parameter/Efficiency of the stemming material										
S. No.	Type of Stemming material	Horizontal holes	Dip holes	Rise holes	Watery holes	Dust Suppression	Fragmentation	Ground Vibration control	Noise control	Remarks
1	Moist Clay	<b>G</b>	<b>G</b>	<b>G</b>	<b>G</b>	<b>NA</b>	<b>G</b>	<b>G</b>	<b>G</b>	Cheapest
2	Sand	<b>VG</b>	<b>VG</b>	<b>VG</b>	<b>VG</b>	<b>NA</b>	<b>VG</b>	<b>VG</b>	<b>VG</b>	Inserting Difficult
3	Sand-Clay Mixture	<b>VG</b>	<b>VG</b>	<b>VG</b>	<b>VG</b>	<b>NA</b>	<b>VG</b>	<b>VG</b>	<b>VG</b>	
4	Flyash-Clay	<b>VG</b>	<b>VG</b>	<b>VG</b>	<b>VG</b>	<b>NA</b>	<b>VG</b>	<b>VG</b>	<b>VG</b>	
5	PVC Ampoules					<b>E</b>				Suitable for gassy mines
6	Water or Gel filled Ampoules					<b>E</b>				Suitable for gassy mines
7	Stemming Plugs	<b>E</b>	<b>E</b>	<b>E</b>	<b>E</b>	<b>E</b>	<b>E</b>	<b>E</b>	<b>E</b>	Most efficient in all cases

Performance of the Stemming material : **G** -Good **VG**- Very Good **E**- Excellent **NA**- Not Applicable

### VI. CONCLUSION

- a. Sand is the best stemming material among all other compositions of stemming. Sand is found to effectively confine the high-pressure stress produced by blasting. But then inserting into horizontal, inclined upward holes is difficult in manual stemming.
- b. A mixture of Fly ash-red clay can be used effectively in underground coal mines as it is available cheaply.
- c. In watery places, the performance of stemming with fly ash-red clay is reduced. But sand is effective in this situation.
- d. Stem plugs can be effectively used in all the situations and the performance is not affected in watery places, dip or rise side etc.
- e. It is easier to insert any type of plug (as discussed in preceding sections) into the holes than other conventional stemming in all the situations.

### REFERENCES

- [1] Calvin J. Konya, 1978G - "the effects of stemming consist on retention in blast holes." - P 102 Ph.D. West Virginia University Morgantown, West Virginia
- [2] Adhikari, G. R., 2007. "Examining blast design in India, Tunnels & Tunnelling" International, November, pp.25-28.
- [3]. "Explosives and blasting techniques" by Dr. Gyanindra Kumar Pradhan, Minetech Publications, Bhubaneswar, India , pp 96-102
- [4]. Gunnar Johnsson and Wolfgang Hofmeister,1961. "The Influence of stemming on the Efficiency of Blasting using 36 mm short holes", (International, Symposium on "Mining Research" proceedings of Symposium held at the University of Missouri, February, 1961 Edited by George B. Clark Missouri school of Mines and Metallurgy).
- [5]. Jack Eloranta, 1997. "Stemming selection for large diameter blast hole International Society of Explosives Engineers (ISEE)", Cleveland, Ohio, 95/96.
- [6]. John W. Kopp, 1987. "Stemming ejection and burden movements of small Borehole blasts" (Second International Symposium on Rock fragmentation by blasting Key stone, Colorado. August 23- 26,1987)

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- [7]. Konya, CJ, D Skidmore, and F. Otuonye,1981. "Control of Air blast and Excessive Ground Vibration from Blasting by use of Efficient Stemming" (OSM contract G5195035, Ohio state U.), June, 1981, 199 p.p. Ph.D. West Virginia University Morgantown, West Virginia Jim Davis Continental Oil Company
- [8]. Ron Frye and Dan Leach, 1997. "Improved Fragmentation via the use of Blast Control Plugs" presented at the Seventh High Tech Seminar, Orlando, Florida- July 28, 1997.
- [9]. Stephen H. Chung and Graham G. W. Mustoe, 2002. "Effects of Particles Shape and Size Distribution on Stemming Performance in Blasting" pp. 288-293, ([doi](https://doi.org/10.1061/40647(259)51) 10.1061/40647(259)51)
- [10]. Van Dolah, R.W., N.E Hanna, and R.L. grant,1961. "Relative efficacy of Stemming materials in reducing incendivity of permissible explosives", US Bureau of Mines RI 5863, 1961, 8 p.p.
- [11] Atlas Powder Company, 1987, Konya and Wallei, 1990, Ash, 1990, Poisson et al, 1994, Dick et al, 1986, ICI, 1993.
- [12] [https://www.leg.state.mn.us/docs/2015/other/150681/PFEISref\\_1/Dyno%20Nobel%202010.pdf](https://www.leg.state.mn.us/docs/2015/other/150681/PFEISref_1/Dyno%20Nobel%202010.pdf)
- [13] [https://shodhganga.inflibnet.ac.in/bitstream/10603/131718/13/13\\_chapter%206.pdf](https://shodhganga.inflibnet.ac.in/bitstream/10603/131718/13/13_chapter%206.pdf)