कोल इण्डिया Coal India

सीएमपीडीआई मिनी रत्न cmpdi Mini Ratna

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TechVista

A CMPDI initiative

Inaugural Issue

CMPDI

Digitization of the Coal Sector Through 5G Technology

The Ministry of Coal (MoC) has designated CMPDI as a "Centre of Excellence (CoE)" for the development and expansion of 5G technology in the coal sector. In line with this vision, CMPDI has successfully established a 5G Use Case Lab in Ranchi. The potential use cases to be developed and tested at Lab includes Voice and video communication, Video surveillance and tracking, 5G Drone monitoring and inspection, IOT sensors for vehicle, environmental monitoring and worker's safety, along with customized use cases may be developed as required by coal industry. Under the implementation of 5G technology at the mine level, selected Use cases tested along with a 5G CNPN/private network at Amlohri open-cast mine of NCL. The objective of this initiative is to demonstrate the transformative capabilities of 5G to enhance operational efficiency, safety, and automation in open-cast mining operations.

CMPDI also conceptualized and demonstrated India's first private 5G network in coal mining at NCL's Amlohri Mine at IMC-2023 demonstrating 5G use cases like drones and AI cameras, setting the stage for digital transformation in the sector, and highlighting future tech like Digital Twins for coal mining. CMPDI is also continuously showcasing 'how 5G technology is revolutionizing the coal mining industry' at the India Mobile Congress 2024, 2025 at New Delhi. CMPDI used IMC as a platform to prove 5G's transformative potential in coal mining, establishing a strong foundation for digital innovation in the Indian mining sector.

COAL STOCK VOLUME MEASUREMENT USING UAV (UNMANNED AERIAL VEHICLE) / DRONE BASED PHOTOGRAMMETRY TECHNIQUE

Bhuvnesh Kumar Gupta,

Mohit Rastogi

Introduction

The Geomatics Division at CMPDI (HQ) has been conducting UAV drone surveys since 2019 for multiple applications such as topographic mapping, contour generation, sand replenishment studies, coal stock measurement, coal fire mapping, identification of unstable sites, and fly-through visualizations of orthomosaic datasets for areas of interest.

Coal Stock Measurements is a very important activity in coal mining operations, CMPDI had conducted a number of studies to establish a technique of measurement of Coal Stock using Unmanned Aerial Vehicle mounted with Optical sensor. On the basis of studies, the UAV/ Drone based Photogrammetric Technique has also been incorporate in the Yellow Book-- Code for Uniform System of Maintenance Control and Verification of Coal Stock in All Mines of Coal India Limited.

A Standard Operating Procedure (SOP) has also been formulated by CMPDI for Coal Stock Measurements using UAV based photogrammetry.

Methodology for coal stock assessment

For coal stock volume measurement, the boundary of the coal heap is first delineated and provided in the form of a KML file for planning the drone survey. The procedure follows the guidelines of the Yellow Book, Revision 2020, updated in November 2025

Ground control point configuration

Prior to flying, **Ground Control Points (GCPs)** are established on and around the coal heap as per the Yellow Book specifications. The GCPs are designed to be clearly visible in drone images, and at least three permanent GCPs are set up around the periphery for repeated use.

The spacing of GCPs on the top of the coal heap is kept at a maximum of 100 m, with a minimum of three GCPs on the top surface. The number of GCPs placed on the ground around the periphery is maintained at a minimum of 1.5 times the number of GCPs placed on the top of the heap

Post-processed kinematic (PPK) enabled drones and dual-frequency DGPS instruments are used for accurate Position of point (X, Y, Z)

Figure: GCP and DGPS instrument

Drone platform and sensor configuration

After GCP marking, the drone survey is carried out using an oblique, multi-angle camera (typically a 5-angle camera), which captures images from five viewing directions simultaneously. This configuration improves point cloud density and 3D model accuracy, which are critical for reliable **drone photogrammetry.**

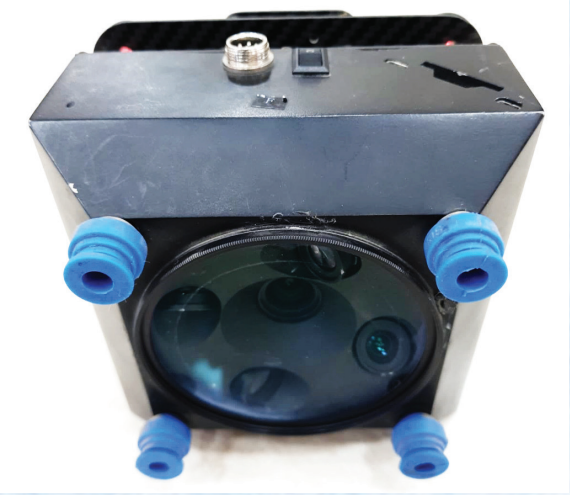


Figure: Oblique camera

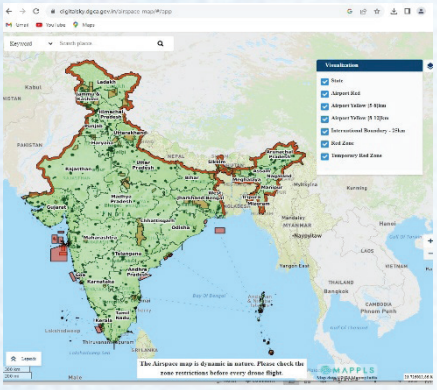
The drone flying height is kept low enough to maintain a ground sampling distance (GSD) of approximately 1.0 cm. CMPDI uses both quadcopter and hexacopter platforms to measure coal stock volumes, as these multirotor platforms provide a stable platform and better low-speed manoeuvrability compared to fixed-wing drones.

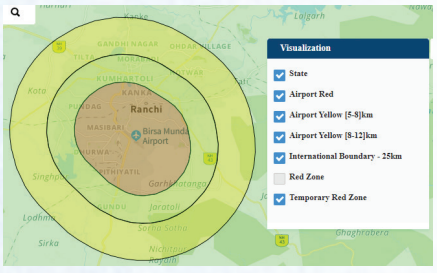
Quadcopter Drone

Quadcopter Drone

Regulatory framework

For commercial drone operations in India, a permit is required for all categories except Nano drones flown below 50 ft and Micro drones flown below 200 ft. All drones must be registered with the DGCA, and operators must hold a **DGCA-approved Remote Pilot Certificate**. Registration and operational permissions are obtained through the Digital Sky Platform, which serves as single-window online portal for drone-related approvals





Before each flight, GCPs are marked on the ground and on the coal heap. The flight plan is then prepared in Bluefire Touch (or equivalent mission-planning software) using the KML boundary of the stockpile.

GCP on Google Earth Image

Drone images and GCP

Following the flight, all images and GCP locations are verified and geotagged using dedicated mapping or "map assist" software. This step ensures consistency between the image positions, GCP coordinates, and position and orientation system (POS) data prior to photogrammetric processing.

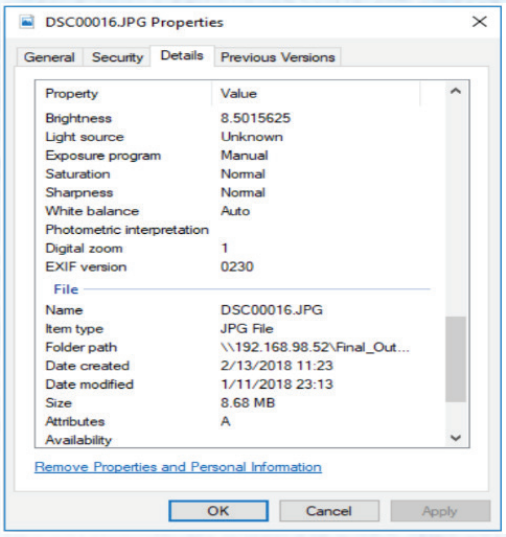


Image before Geotag

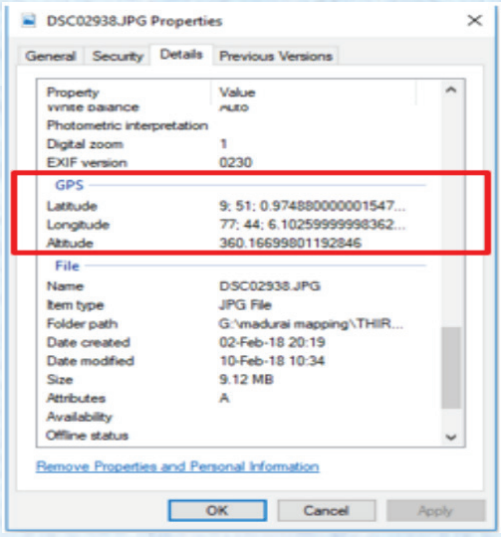


Image after Geotag

Drone data processing workflow

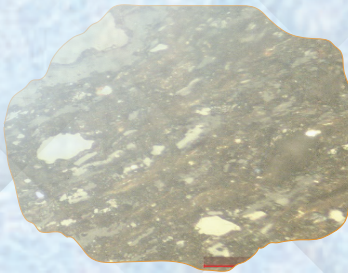
Drone image processing is carried out using professional photogrammetry software. CMPDI currently uses licensed **Agisoft Metashape 2.2.3** for this purpose. The typical data processing workflow is as follows.

- Image geotagging using POS data.
- Project creation in the photogrammetry software.
- Setting of appropriate horizontal datum and map projection (e.g., UTM) for the project.
- Import of georeferenced images into the project
- Initial image alignment to generate tie points
- Tie point generation and refinement
- Import of GCP coordinates obtained after DGPS post-processing.
- Image realignment with GCP constraints to improve absolute accuracy.
- Generation of a dense point cloud.
- Digital Elevation Model (DEM) generation from the dense point cloud.
- Classification of ground points from the point cloud to separate ground and non-ground features.
- Digital Terrain Model (DTM) generation from classified ground points.
- Orthophoto generation (orthorectified imagery).
- DTM-to-DTM volume computation in **Global Mapper** using pre- and post-survey DTMs or DTM and original ground level (OGL)

Tie points, dense point clouds, DEMs, DTMs, orthomosaics, and 3D models are generated as intermediate products and are visually inspected for errors, gaps, and artifacts before final volume computation.

Volume computation of coal stock

After completion of data processing, coal stock volume is computed using the input OGL and the marked coal heap boundary data supplied by the concerned colliery. The volume is calculated in UTM projection by computing the differences between DTMs (DTM-to-DTM method), generally using Global Mapper or equivalent GIS/3D analysis software.



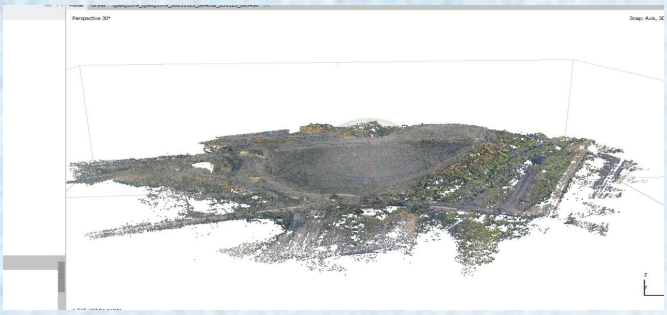


Figure: Tie points

Figure: Point cloud

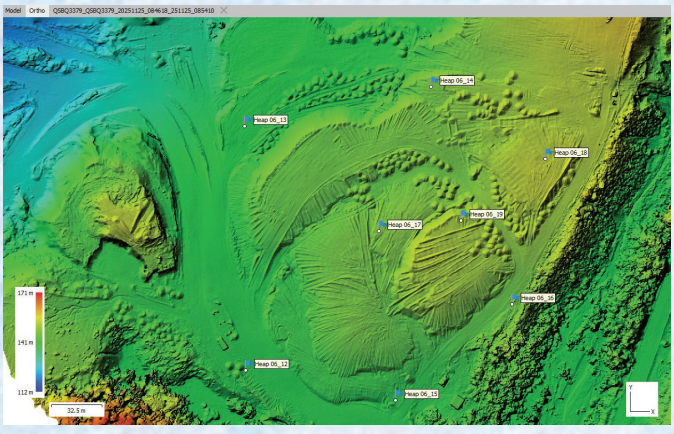


Figure: DEM

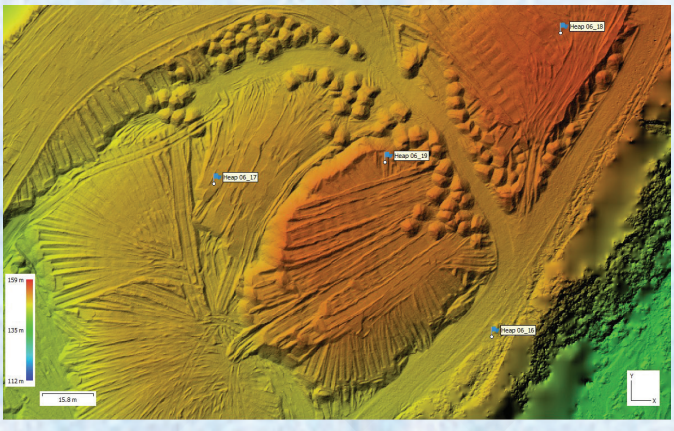


Figure: DTM

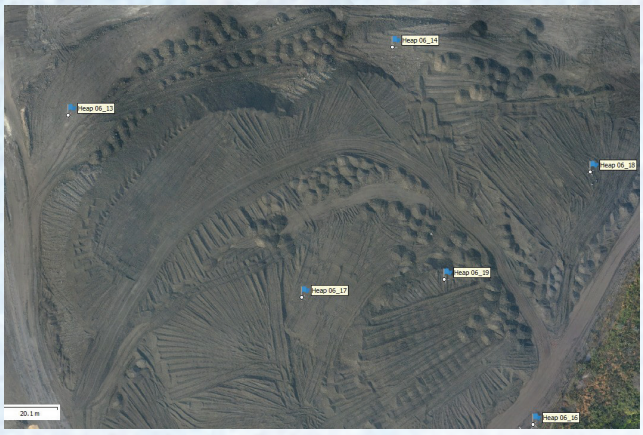


Figure: Orthophotomosaic

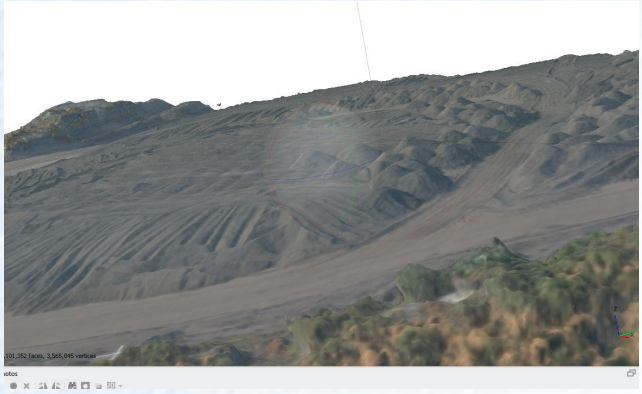


Figure : 3D model

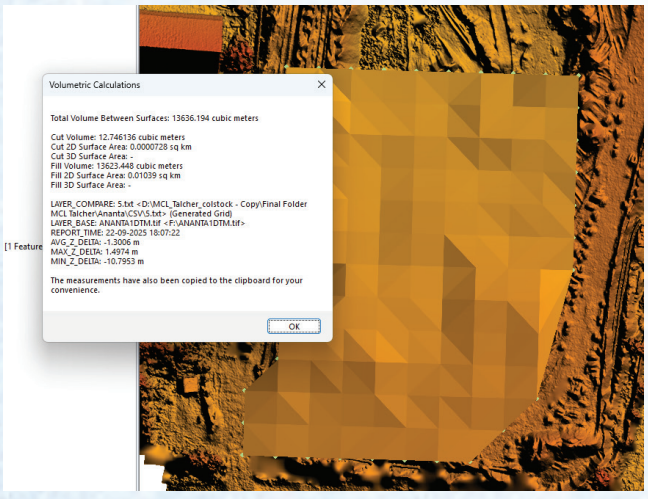


Figure: Volume calculated using Global mapper

Conclusion:

UAV/Drone based photogrammetry technique provides an accurate volumetric analysis.

This approach provides repeatable, and auditable estimate of coal stock volume and supports reconciliation of physical stock with production and dispatch records.

TRANSFORMING DEEP AND UNMINEABLE COAL RESOURCES: COAL INDIA LIMITED'S R&D INITIATIVES IN UNDERGROUND COAL GASIFICATION

Clean Energy Department, CMPDI (HQ), Ranchi

INTRODUCTION

India possesses vast reserves of non-coking coal, nearly 80% of which is currently consumed by thermal power plants. With growing environmental concerns and rapid advancement of renewable energy, there is an urgent need to explore cleaner and more sustainable alternatives for coal utilization. Coal gasification offers a promising pathway to ensure energy security, environmental responsibility, and economic benefits for coal-dependent states.

Coal gasification enables conversion of coal into synthesis gas (syngas), which can be further processed into chemicals, fertilizers, hydrogen, and cleaner fuels. Recognizing this potential, the Hon'ble Prime Minister of India has set a vision to gasify 100 million tonnes of coal by 2030, with Coal India Limited (CIL) playing a central role in achieving this objective.

Among various gasification technologies, Underground Coal Gasification (UCG) stands out as a transformative solution. UCG converts coal into syngas directly within the coal seam, eliminating the need for conventional mining. This technology offers a viable means to unlock deep-seated and unmineable coal resources while minimizing surface disturbance. With appropriate environmental safeguards, UCG has the potential to support India's transition towards a cleaner and more self-reliant energy future.

UNDERGROUND COAL GASIFICATION PROCESS

Underground Coal Gasification is an in-situ thermo-chemical process carried out in deep coal seams using surface-drilled wells. The process begins with detailed site selection based on geological, hydrogeological, and environmental evaluations. Exploratory drilling and monitoring wells are established to assess coal quality, groundwater conditions, and rock stability. Injection wells are drilled to introduce air or oxygen into the coal seam, initiating controlled ignition. At elevated temperatures, coal undergoes gasification, producing syngas - a mixture primarily consisting of hydrogen, carbon monoxide, methane, carbon dioxide, and minor constituents. The syngas flows to the surface through production wells, where it is separated from condensates and processed for utilization. During pilot operations, excess syngas is safely flared to ensure operational safety and environmental protection.

SITE SELECTION CRITERIA

Successful UCG implementation depends on stringent site selection. Suitable coal seams must be sufficiently deep, thick, and continuous, with strong and impermeable overlying strata to ensure containment. Geological stability with minimal faults and fractures is essential. Coal reactivity and low impurity levels enhance gasification efficiency.

Environmental considerations include isolation from potable groundwater sources, natural hydrogeological barriers, low subsidence risk, and low population density. Accessibility for surface infrastructure and proximity to syngas-consuming industries further improve project viability. Social acceptance and environmental permissibility remain key factors in long-term sustainability.

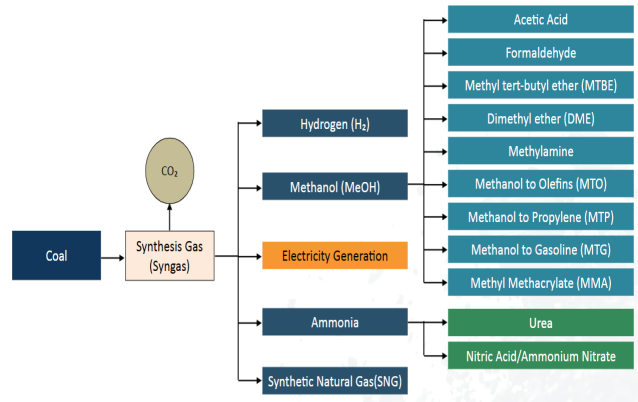
In addition, long-term operational monitoring and post-gasification management capabilities must be considered during site selection. The site should allow installation of comprehensive monitoring systems for pressure, temperature, gas composition, groundwater quality, and rock deformation throughout the project life cycle. Adequate land availability is required for setting up buffer zones, safety systems, and emergency response infrastructure. The potential for post-operation site rehabilitation, including cavity stabilization and environmental restoration, should

also be evaluated in advance. Selecting sites that support effective monitoring, regulatory compliance, and safe closure planning ensures that UCG operations remain environmentally responsible and technically manageable over the entire project lifespan.

COMMERCIAL UTILIZATION OF SYNGAS

Syngas produced through UCG can be used for power generation, hydrogen production, and as feedstock for chemicals such as methanol, ammonia, and synthetic fuels. These applications make UCG an important contributor to India's energy diversification, fertilizer security, and chemical industry growth.

CIL'S R&D INITIATIVE ON UCG

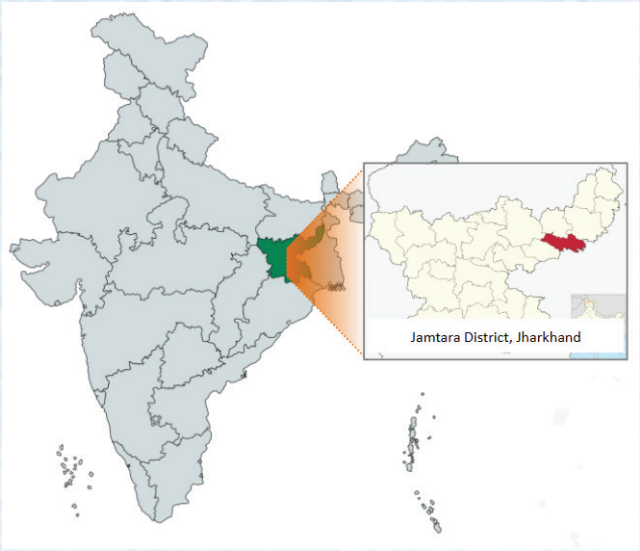


Coal India Limited is implementing a Pilot Underground Coal Gasification Project as part of its R&D initiative to establish UCG technology under Indian geo-mining conditions. The project is led by CMPDI, Ranchi, and Eastern Coalfields Limited (ECL), in collaboration with M/s Ergo Exergy Technologies Inc., Canada.

The project targets the Kasta West coal block in Jharkhand and is structured in two phases. Phase-I involved site characterization, drilling of exploration and monitoring wells, laboratory testing, environmental clearances, modelling and simulation, and preparation of the pilot plant design. Phase-II will include construction, commissioning, operation, optimization, and post-closure monitoring of the Pilot UCG plant.

KEY OUTCOMES OF PHASE-I

Phase-I investigations confirmed the technical and environmental feasibility of UCG at the Kasta West site. Geological, hydrogeological, and rock mechanics modelling demonstrated that gasification would remain confined within the coal seam, with negligible groundwater impact and no perceptible



surface subsidence. Coal testing established favourable reactivity and gasification characteristics.

Monitoring systems, including groundwater sampling wells and rock deformation sensors, validated that the pilot operation poses minimal environmental risk. These findings provide a strong technical foundation for Phase-II implementation and future commercial projects.

CHALLENGES AND WAY FORWARD

Despite its promise, UCG faces challenges such as technological adaptation to Indian conditions, and stringent environmental safeguards. Addressing these challenges requires advanced monitoring, site-specific modelling, and integration of carbon capture, utilization, and storage (CCUS).

A supportive policy framework, fast-track approvals, international collaboration, and public–private partnerships are essential. With systematic planning and responsible execution, UCG can emerge as a vital component of India's low-carbon, self-sufficient energy strategy.

CONCLUSION

The successful completion of Phase-I of the Pilot UCG project at Kasta West marks a significant milestone in India's clean coal initiatives. The outcomes demonstrate that Underground Coal Gasification can be safely and efficiently implemented under Indian conditions. With continued R&D, regulatory support, and technological innovation, UCG holds the potential to play a transformative role in India's sustainable energy future.

INNOVATION IN BLASTING: STEM PLUG FOR ENHANCED PERFORMANCE IN OPENCAST MINES

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INTRODUCTION

Blasting is the most critical operation in opencast mining, directly influencing productivity, safety, fragmentation quality, and environmental performance. Traditionally, drilled blast holes are stemmed with drill cuttings to confine explosive energy. However, this conventional stemming often fails to provide complete confinement, resulting in:

- Excessive dust and fumes
- Higher ground vibrations
- Increased fly-rock risk
- Poor fragmentation
- Energy losses due to stemming blowout

To overcome these challenges, **Stemming Plugs (Locking Caps)**—synthetic rubber, conical or cylindrical devices—have been introduced as an innovative alternative for blast-hole sealing.

WHAT IS A STEM PLUG?

A stem plug is a **synthetic rubber device**, engineered to seal the collar of a blast hole more efficiently than traditional drill cuttings.

Key characteristics include:

- Material: Synthetic Rubber
- Hardness: 75–80 Shore-A
- Tensile Strength: 4.0–4.5 MPa
- Thickness: 3 mm (optimized strength–weight balance)
- Shape: Conical/Cylindrical for better wall grip

Its flexible design ensures **tight adhesion with blast-hole walls,** improving confinement and enabling fuller utilization of explosive energy.

INNOVATIVE NATURE OF STEM PLUG

The Stem Plug represents a step change in blasting practices for opencast mines:

1. Controlled Energy Utilization

By preventing premature venting of gases, the plug forces energy deeper into the rock mass—achieving optimum breakage.

2. Reduced Environmental Footprint

Significantly reduces **dust, noise, vibration, air overpressure,** and **fly rock,** meeting regulatory requirements such as consent to operate (CTO) conditions mandated by State Pollution Control Boards.

3. Improved Fragmentation Quality

High-speed camera footage and WipFrag analysis confirmed that blasts with stem plugs produce **finer, more uniform fragments,** reducing need for secondary blasting.

4. Enhanced Mine Safety

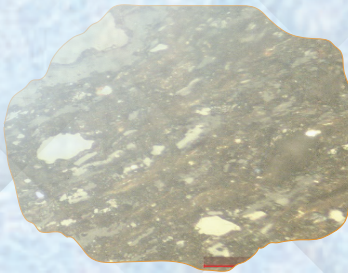
Better confinement drastically reduces fly-rock incidents, protecting personnel, machinery, and surrounding habitats.

5. Low Cost, High Impact Innovation

Simple to install, reusable in many designs, and highly effective—ideal for large-scale opencast operations.

BENEFITS OBSERVED FROM FIELD TRIALS IN OPENCAST MINES

Scientific studies and controlled trial blasts conducted at **Jayant OCP** and **Khadia OCP, NCL**, confirm significant benefits when using stemming plugs over conventional stemming.



1. IMPROVED FRAGMENTATION

- More uniform muck-pile
- Reduced oversized boulders
- Faster loading and better shovel cycle times
- Higher productivity of HEMM fleet

Fragmentation analysis (WipFrag) consistently shows **lower mean fragment size** in plug-assisted blasts.

2. SIGNIFICANT REDUCTION IN DUST EMISSION

During blasting, the plug prevents sudden release of gases and dust.

Measured improvements:

Reduction in **PM10** and **PM2.5** levels during blasting

- Lower visible dust plume
- Compliance with environmental norms

This makes stem plugs especially valuable in mines particularly near habitation or sensitive receptors.

3. REDUCTION IN GROUND VIBRATION & AIR OVERPRESSURE

Well-confined blasts with stem plugs generate **lower PPV values**, reducing the risk of structural impact.

- Measured PPV reduced at monitoring stations
- Higher frequency vibrations (safer and less damaging)
- Better compliance with DGMS standards

4. MINIMIZED FLY ROCK

Fly rock poses a major risk in surface mining. Stem plugs significantly minimize this hazard by:

- Preventing stemming ejection
- Holding the top column intact
- Forcing explosive gases into the rock mass rather than upward

All trial blasts with stem plugs recorded **fly rock within safe limits.**

5. ECONOMIC BENEFITS

- Reduction in drilling & blasting cost due to improved fragmentation
- Decreased secondary blasting
- Faster loading & hauling (higher production/ hour)
- Lower wear on crusher units
- Reduced delays due to dust/noise complaints

Overall, stemming plugs contribute to **higher production at lower cost**

CONCLUSION

The introduction of **Stemming Plugs/Locking Caps** in opencast mining marks a **significant technological advancement.** The innovation ensures:

- Maximum utilization of explosive energy
- Improved environmental compliance
- Enhanced safety
- Better fragmentation and productivity

Earth Science Museum of CMPDI, Ranchi

At one corner of Ranchi city, there is a hidden treasure of knowledge and interest which is not known to many. It is the small but remarkably elegant display of information and items related to the creation of the universe and the many- splendoured aspects, riches and resources of our mother earth. The Earth Science Museum at the ground floor of the headquarters of CMPDI is really fascinating in its content and display and is a source of great interest to all seekers of knowledge. CMPDI, as an intellectual organisation was willing to establish such a museum which would display aspects of mining but with a much broader background of overall information and knowledge for public interest. Around the year 1991, the Coal India Management blessed this endeavour and a basic design of the museum was prepared by CMPDI in-house Architect. Upon approval, the famous artist and museum implementer, Shri R A Dutt, was selected through due procedure to construct and install the display items.

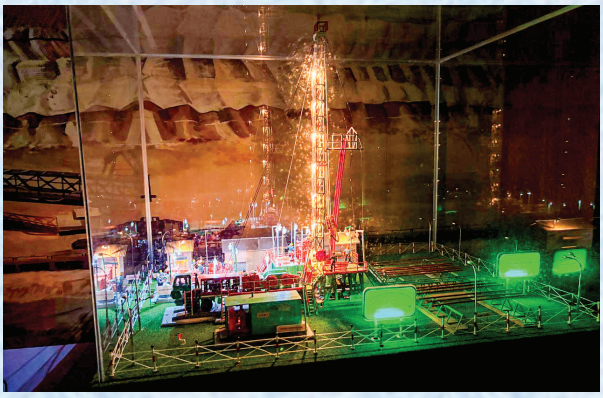
The beautifully laid out Earth Science Museum was inaugurated in the year July 1991 and starts with the Story of the creation of the universe 1400 Crore years ago, then the creation of the solar system and our planet earth around 450 crore years ago. These and many other models and dioramas in this museum are mechanically animated and make actual movements to the interest of the visitors. Gradually, the displays tell the stories and mechanisms of volcanoes, the ocean, the advent of life on earth and its evolution. Many rare and genuine samples like shells, fossils, dinosaur bones, geological treasures like a variety of crystals and gemstones, are also displayed here. Landforms created in limestone deposits due to water action i.e. Karst landforms, including Stalactite, stalagmite, etc. are also depicted. Samples of petrified trunks are also stored in the museum. The evolution of man and how cave men lived, are displayed through models. Items of geological interest like the cross-section of the earth, hot springs, petroleum extraction from seabed and its refining are also shown. An interesting model shows the landing of the lunar module on the moon.

After this general display, there is a specific gallery dedicated to displays related to coal mining. Coal samples of various types are displayed here with their technical properties and grades explained. A large model shows the entire activities of one typical underground coal mine and its allied activities. There is working model of mechanized open cast mine and CBM utilization & extraction which have been made by CMPDI's in-house technician and is a wonder with all machines and vehicles actually moving. At the end, there is the historic iron capsule which was used to save the lives of the trapped miners in the Mahavir colliery mishap in 1989.

CMPDI Earth Science Museum is now also brought on digital platform by introducing audio visual multimedia system by deploying state of the art digital technology such as multi touch screen display/kiosks, AR/VR Applications, holographic projections etc. With content management system.

The Earth Science Museum is, thus, a mine of information, interest and education.

GLIMPSES OF **EARTH SCIENCE** MUSEUM



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