

# Application of pre-tensioned cable bolting (bulbed type) at Adriyala longwall project

*High capacity longwall technology introduced at Adriyala longwall project with a rated capacity of 3.0Mt per annum. Huge machinery required to be installed in longwall face and gate roads. This machinery required wider gate roads of 5.2 to 5.5m widths. The immediate roof in gate roads is coal with thickness of 4.0mtr. Immediate roof consists of 2 clay bands of 0.3m and 0.7m thickness within the bolted and above the bolted horizon causing bed separation in the immediate roof, resulted in that, during development of gate roadways, 85% of roadways are good in condition, 15% of gate roads were observed with guttering, geological disturbances, water seepage, and in some areas horizontal stress effect is also noticed. While retreating of longwalls, major disturbances were observed in gallery ahead of the longwall face, and also in cut through galleries and adjacent gate roads subjected to abutment loading. To overcome the above issues, Pre-tensioned bulbed type cable bolting is introduced first time in India as secondary support in gate roads of longwall panel to ensure its stability over long period and also to eliminate standing support in gate roads ahead of the longwall face. In this paper, the installation and performance of bulbed type cable bolt is discussed in detail.*

## Brief description of Adriyala longwall project

**R**amagundam coal belt is located in the Peddapalli District of Telangana state in Godavari valley coalfields. The area of the present Adriyala longwall project is 3.4 sq km. and bounded by North latitude 18° 03' 39" to 18° 04' 34" and East longitude of 79° 03' 34" to 79° 05' 35". It is covered by Survey of India Topo Sheet No. 56N/10. This project envisages extraction of Nos. I, II, III and IV seams within the identified area below existing dip side boundary of GDK 10 incline mine. The total geological reserves are 110 Mt in which the extractable reserves are 78.59 Mt and the life of the project is 35 years with targeted production of 2.81 MTPA. These were from 400m to 650m depth range and

further exploration was going on up to 900m depth to plan for future panels which will increase life and reserves.

The longwall panel No.1 was about 2320m long and face width was 250m with a height of extraction of 3.5m. In the LWP No.1 3.5Mt coal was extracted. Presently, LWP No.2 is under retreat. LWP No.3 is being developed with bolter miner.

## NEED OF WIDER GATE ROADS AT ALP

Longwall panel Nos.1&2 gate roads are developed with 5.2m × 3.6m dimension galleries. These wider galleries are required to facilitate belt conveyor, energy train of longwall machinery, and movement free steered vehicles for material transportation. Panel No.3 gate roads are planned to develop with 5.5m × 3.6m dimension galleries with bolter miner of Joy Mining Company. This width at greater depth requires additional support in addition to roof bolting and rigid wire mesh to withstand longwall abutment pressures. To mitigate the effect of longwall abutments, as per advice of the scientific organization and geotechnical consultants cable bolting were introduced at Adriyala. Strata problems were encountered while widening longwall panel No.1 installation face with 8m width. As per the recommendation of Geotech consultant, Pre-tensioned cable bolting (6.1m) was introduced for the first time for better strata control and to eliminate vertical support in face dip to facilitate the movement of diesel vehicles. After supporting with cable bolts, the face dip was widened to 8m without any strata control problems.

## INTRODUCTION OF PRE-TENSIONED BULBED CABLE BOLTS AND DRIVEAGE OF 8M WIDE INSTALLATION ROADWAY WITH WEAK COAL ROOF

Strata problems were encountered while widening longwall panel No.1 installation face with 8m width. The installation face was planned to develop with 8m width with weak coal roof (bottom section) having the RMR of 41.4. The installation of vertical supports as per the practice of earlier longwalls is not adaptable because of installation of powered supports and longwall machinery shall be done by the diesel vehicles. The vertical supports will obstruct the movement of diesel vehicles and delay the process of the installation of longwall equipment in the installation roadway. Hence, pre-tensioned cable bolting (6.1m) was introduced for the first time for better strata control and to eliminate vertical support in face dip to facilitate the movement of diesel vehicles. After

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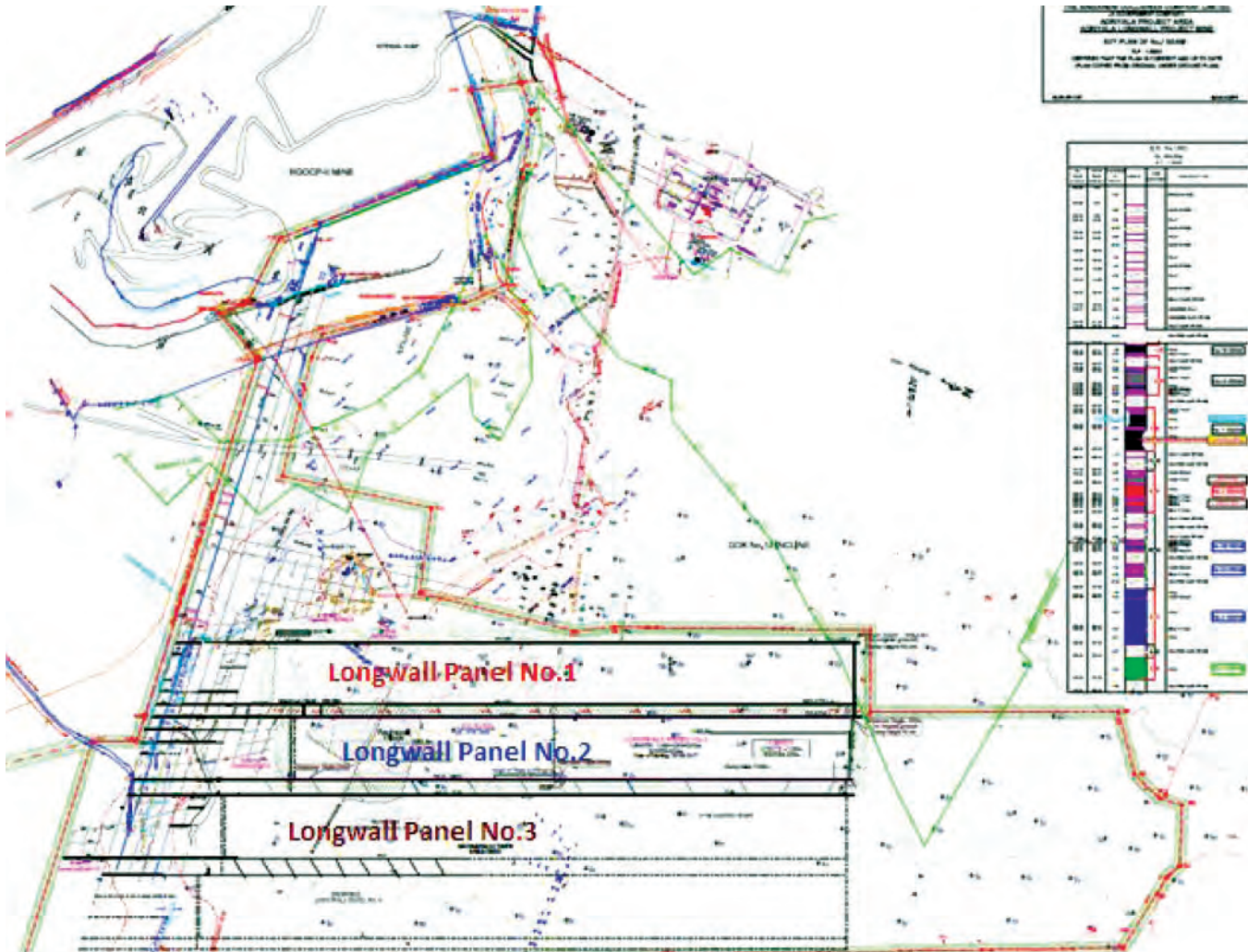


Fig.1 Key plan of Adriyala longwall project

supporting with cable bolts, the face dip was widened to 8m without any strata control problems.

#### PRE-TENSIONED BULBED CABLE BOLTING

Pre-tensioned bulbed cable bolts are 60t capacity with 6.1m length, in which top 900mm will be resin anchored for 30t pre-tension. The pre-tensioning of 30t will ensure that the immediate coal layers will be binded together to increase the frictional resistance between the layers and created the compression zone. A special made of tensioning jack and barrel and wedge were used for the pre-tension purpose. The remaining 5m will be post grouted with cement for full column grouting by filling the entire hole and also ensure the strata consolidation by filling the existing cracks in the roof. The installation roadway of 8m width was

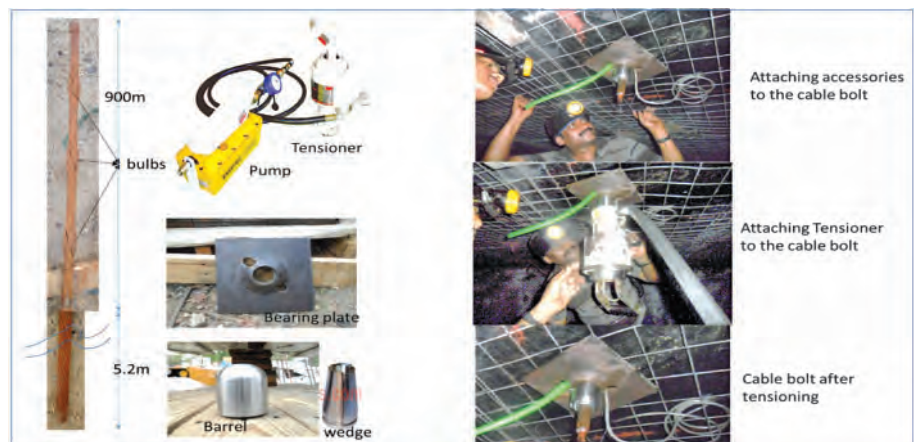


Fig.2 Bulbed cable bolts and accessories

supported with these bulbed cable bolts improved the roof condition and ensured the successful installation of longwall machinery. The gate roads were also supported with these bulbed cable bolts as per SSR during the retreat of longwall



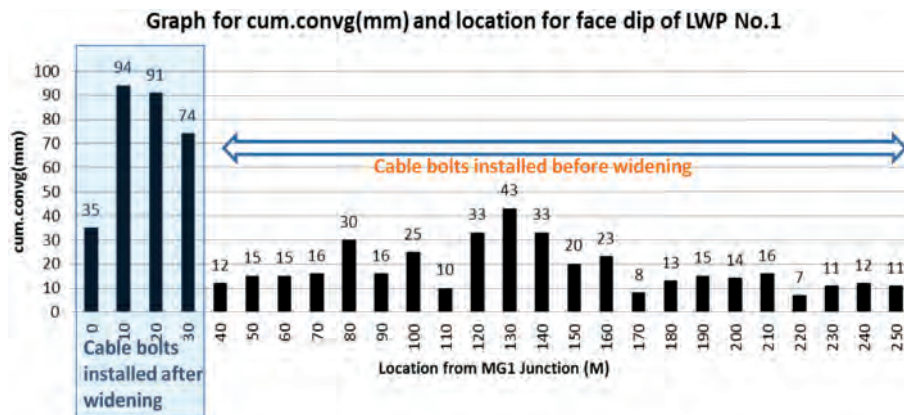


Fig.3 Graph showing the convergence status in face dip of LWP No1

face as the vertical supports are not feasible. No strata problems were occurred in the gate roadways and the roof is effectively controlled from the longwall abutment pressures with the use of bulbed cable bolts.

#### DRIVAGE OF INSTALLATION ROADWAY

The drivage of installation roadway of panel no.1 was done in two stages. During the first stage, it was developed with 5m width and in the second stage it was widened to final 8m width. Due to non-availability of bulbed cable bolts, the first 40m was widened by supporting only with roof bolts with extra density. But sudden convergence was noticed after drivage of 40m and the widening was stopped. The widening was resumed after supporting with the bulbed cable bolts in the already widened area up to 40m and in the unwidened area before widening. After installation of cable bolts, the convergence was stabilized in the already widened area and the total installation roadway widening was completed successfully without any strata problems and the convergences were within the permissible limits (Fig 9).

#### SECONDARY SUPPORT IN GATE ROAD DURING RETREAT OF LONGWALL PANELS

High capacity longwall equipment compose of heavy machinery in gate road, particularly in main gate up to 30m from longwall face. As front abutment zone lies within 20m to 30m from face, gate roads needed to support with secondary support in addition to roof bolts during development. In earlier longwalls the practice is to install hydraulic OC props. Removal of OC props and re-erection of OC props is hindrance to production. Erected props are obstruction to longwall equipment in gate road. To mitigate high front abutment pressure and eliminate productive time consumption, pre-tensioned cable bolting is introduced in gate roads of longwall panels. Cable bolts can be installed prior to longwall retreat mining. Cable bolts of 60t capacity are installed which are better capacity than OC props. Moreover gate road are free from obstruction to advance of machinery in main gate road. In tailgate also material can be transported up to the face without any obstruction. So pre-

tensioned cable bolts are introduced in gate road of longwall panels as secondary support.

#### PRE-TENSIONED CABLE BOLTS

Cable bolts can be used at wide excavations and roadways that are subject to large stress values. The flexible nature of the cables, (of lengths more than gallery height), that lengths far greater than standard roof bolts can be installed into mine roofs to reinforce the softening ground. In some cases cable bolts are termed as long tandems. There are several types of cable bolts available

depending on their purpose:

1. Bird cage cable bolts,
2. Nut cage cable bolts,
3. Flexible cable bolt,
4. Bulb cage cable bolt,
5. Wire ropes.

Bulb cage cable bolts among them are being used at Adriyala longwall project have shown better results on their application. The bulb cage cable bolts of 23.5mm dia, 6.1meters in length, 3nos of 36mm bulbs of equally spaced with in one meter at one end are used, the other end is given pre-tension. After pre-tensioning, cement is injected into rest of the column of bolt hole.

#### WHAT IS PRE-TENSIONING?

In mines, pre-tensioning is the practice of applying a pre-determined load to rock reinforcement cable bolts during or shortly after installation. It was applied to resin partially anchor type cable bolts. It is also necessary to tension the end plate to the roof to make the bolt effective as a support. Tensioning loads as high as 30 tonnes are now used with higher capacity systems as bulb cage type cable bolts. The term pre-tensioning is used in mining, mechanical and civil engineering to describe three somewhat different processes. It is therefore useful to compare these to avoid confusion and to see to what extent ideas and practices are generally applicable.

#### Procedure for cable bolt installation

Installation of pre-tensioned cable bolts have several operations in sequence, they are of selection of site, drilling, resin insertion, cable bolt insertion, spinning and churning the cable bolt, accessories insertion, pre-tensioning the cable bolt, post grouting with cement injection (bottom up method).

#### EQUIPMENT AND MATERIAL FOR CABLE BOLTING AT ADRIYALA

##### 1. Cable bolts (bulb cage type)

Cable bolts are supplied by DSI Australia, CSK

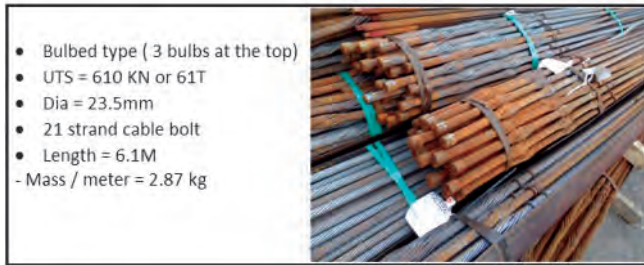


Fig.4 Bulbed type cable bolts

Technologies India, and Minnova Australia.

## 2. Barrel and wedges

- Used to secure roof plates on 23.5mm diameter  $\times$  21 wire strand bolts and prestress the cable bolts.
- Load bearing capacity = 52 to 55 tonnes
- Each wedge consists of three segments, secured by a ring to ensure wedge alignment and initial clamping.



Fig.5 Barrel and wedges

## 3. Bearing plates



- 200mm X 200mm
- Thickness = 16mm, 12mm
- Domed type to suit barrel and wedge
- Holes for inserting Grout tube and breather tube

Fig.6 Barrel and wedges

## 4. Resin capsules



- 36 mm dia.
- 1000mm length.
- Extra slow set = 5Min.
- Used for point anchor to the cable bolt.

Fig.7 Extra slow set resin capsules 36mm  $\times$  1000mm size

## 5. Spinner or adapter



- Used for churning the cable bolt after inserting the resin capsule
- Suit for the 25mm square drive

Fig.8 Churning adapter for cable bolts

## 6. Tensioner

- Used for giving pre tension up to 30T
- Tensioner Set consists of a hydraulically powered Tensioner unit, foot operated compressed air-hydraulic pump and a 4.5m long hydraulic hose with a pressure gauge calibrated in load units.
- Relief Pressure = 380Bar



Fig.9 Pre-tensioning unit for cable bolts

## 7. Cement (43 grades)

- 8. Drilling of hole and churning of cable bolt can be done with jumbo drill or hydraulic roof bolters, high capacity drill rigs mounted on road header, bolter miner

## 9. Compressor

## 10. Cotton

- Model SIP 100
- Total Weight.....22 Kg.
- Total Height.....44"
- Air Pressure Required.....90-100 CFM at 70-80 PSI Pressure.
- Total Head = 3M - 20 M
- A special grout mixer including 2no drums of 75 liters capacity with mixing blades, air motor and torque multiplying speed reduction gear box



Fig.10 Cement injection pump set

## 11. Cement injection pumps

## 12. Breather tube and grout tube

- Breather tube is used to allow the escape of air from the bolt hole during grouting.



Fig.11 Grout tube

- 6mm outer dia, 4mm inner dia
- Grout tube is normally used to pump cementations grouts for rock and cable bolt in post grouting applications.
- Dia 15mm outer dia, 12mm inner dia

#### 13. Drill rods and drill bits to match with bolting machine

- Dia 42mm, drill rods (32mm dia) to suit 43mm dia hole
- Length of the drill rods required 6m

#### 14. Flexible connecting rods or conduit for inserting resin capsule to the top of hole

### Procedures for installation of cable bolting

#### 1. Selection of site for drilling

As per the site requirement, where cable bolt is to be installed, the site is made level by chipping and dressing. The site is chosen based on mine manger's support design.

#### 2. Drilling

- Drilling can be done by jumbo drill or by hydraulic bolter or any high capacity hydraulic drill rigs.
- Wet drilling by 42mm drill bit is preferred using connecting rods.
- Before drilling, drill rods to be marked to the required length.
- Vertical hole of length of 5.950 meters will be drilled at the site.
- Diameter of hole should be 43mm.
- Flush the hole after drilling for dust particle removal.

#### 3. Resin insertion

- Before inserting the resin into the top of the hole, the hole should be cleared by using flexible connecting rods.
- Then insert the resin (36mm\*1000mm) capsule into the top of the hole by using the flexible connecting rods.
- Ensure that resin retainer is there for holding the resin

capsule at hole top.

- Ensure resin is reached at the top of the hole, by observing the marker for resin position on the flexible connecting rods.
- Remove flexible connecting rods after ensuring that resin is placed at the top of the hole.

#### 4. Cable bolt preparation

- Before using the cable for grouting. It should be clear of slush or mud all along its length.
- By placing it on level ground, breather tube should be attached and tied with plaster around the cable bolt up to resin retainer of the cable bolt.
- The breather tube should be at least 150mm more than the length of the cable bolt for checking air bubbles during cement injection.

#### 5. Cable bolt insertion

- After the preparation of cable bolt, now insert the cable bolt into the hole with bulbs are at the top, up to reaching the resin capsule in the hole.
- Care should be taken not to puncture the resin capsule during insertion of cable bolt.

#### 6. Spinning and churning the cable bolt

- After the insertion of cable bolt into the hole, now keep the churning adapter over the bolter and insert the bottom end of the cable bolt into the churning adapter
- Now slowly push the cable bolt upwards into the hole by spinning and thrust the cable bolt for churning.
- Then hold the cable bolt until setting time of the resin capsules reached.
- Remove the churning adapter.
- Now the cable bolt is point anchored with resin.

#### 7. Accessories insertion

- After completion of cable bolt with resin anchor, insert grout tube about 25cm into hole and 25cm out side the hole and thickly pack the bottom of hole along cable bolt, breather tube and grout tube with cotton.
- Before fixing the bearing plate the grout tube and the breather tube should be passed through the holes of the bearing plates and attaches bearing plate with barrel and wedges.
- Now bolt is ready for pre-tensioning operation.

#### 8. Pre-tensioning the cable bolt

- Place the standard tensioner unit suitable to cable bolt-bearing plate-barrel and wedge combination, on to the cable bolt.
- Release some of the hand pressure tensioner unit to engage jaws.
- Pull tensioner unit down slightly whilst supporting it to



make sure jaws have gripped the cable bolt, then apply tension for 30t by pressing the operating levels.

- After the require load is reached, release the pressure from the hydraulic ram by applying pressure to the release valve by pressing the pump treadle.
- Once the cable bolt has been tensioned and ram pressure release, then remove the tensioner unit by pushing the tensioner up and at the same time pull the release card down to disengage the jaws from the cable bolt.
- Care should be taken that the hydraulic ram fully retracted before tensioning the next bolt.

#### 9. Post grouting with cement injection

- After completion of the pre-tensioning of cable bolt, now cable is ready for bottom up cement grouting.
- For cement injection process, place the mixing chamber at the location of cable bolt.
- Add required quantity of cement and water for grouting cable bolt in the mixing chamber
- For mixing the cement and water, connect the mixing chamber to the compressor unit.
- Then start rotator slowly in the mixing chamber.
- Now the mixture is ready for injection into the hole.
- Place the cement injection pump into the mixture.
- Then connect cement injection pump to compressor hose.
- Now connect the cement injection pump delivery to grout tube which is inserted earlier into the hole through bearing plate.
- Now place the breather tube delivery into the water to observe escape of air from hole.
- Hold the pump delivery firmly, and start the pump and inject the cement into the hole.
- The cement injection should be continue until bubbles stopped from the breather tube delivery that means hole is fully filled up with cement.
- Then, remove cement injection pump delivery and breather tube delivery from water jug.
- Now tied up the grout tube to avoid back flowing of cement grout from hole.

Thus complete operation of installing the cable bolt will be done.

#### Conclusions

Stability of the gate roadways during development and retreat is vital for success of any wider and deeper longwalls

and it can be achieved with proper planning and implementation of standards. Resin anchored bulbed cable bolting with pre-tension is a viable solution for secondary support in high capacity longwall gate roadways and installation faces to withstand for abutment loads and reduce the high convergence rates. It also aids to continuous production without any hindrance.

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#### References

1. Ramesh Kumar B., Chandrasekhar S, and Veera Reddy B. (2015): "Need to think one step ahead – High Capacity Longwalls in India, SCCL experience," in International Mining Conference at New Delhi, India.
2. Ramesh Kumar B., Chandrasekhar S and Veera Reddy B (2016): "Construction and Operation of High Capacity Longwall Project – Adriyala Experience", An international conference on Recent advances in rock engineering, at Bangalore 16-18 November.
3. DSI-Australia Products manuals "http://www.dsiningproducts.com/au/products/rock-and-roof-bolts-/cable-bolt.html"
4. Frith, R. (2016): Geotechnical Challenges and Achievements To-Date at the Adriyala Longwall Project (ALP). In Workshop on successful introduction of high capacity longwall at Adriyala . Hyderabad, India.
5. Frith, R., Reed, G., and Mckinnon, M. (2017): Fundamental principles of an effective reinforcing roof bolting strategy in horizontally layered roof strata and areas of potential improvement. *International Journal of Mini*.
6. Frith, R. (n.d.). Technical reports on strata control on ALP.
7. Mietek Rataj, "Development Of Hi-Ten Bolt In Australian Coal Mines" Research & Development Manager Dywidag-Systems International Pty Limited (DSI) Newcastle, New South Wales, Australia

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