International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 03 | March - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Geotechnical Instruments and the Structural Control Issues with Underground Coal Mining

D KOTAIAH

ASSISTANT PROFESSOR, DEPARTMENT OF MINING ENGINEERING, UCE (KU), KOTHAGUDEM, INDIA

ABSTRACT

The working conditions in underground coal mines are recognised for making them one of the most dangerous industries. Mine employees frequently experience numerous danger factors, which results in significant casualties. Roof falls are one of the main accident causes in Indian underground coal mines. Lack of a method to predict roof falls, which makes it impossible to remove workers before the actual breakdown, is one of the major contributing reasons to such accidents. It is feasible to reduce the number of accidents caused by roof falls by monitoring stratum movement in real-time and analysing the collected data to detect potential roof falls well in advance.

Keywords: Strata Control, Tell Tales, Action Levels, Roof Bolting, Design Monitoring.

1. INTRODUCTION

Faster economic development is more important in developing nations like India. India has legitimate concerns about its energy security because energy is the foundation of all economies. Fossil fuels, mainly coal, will be the mainstay for power generation in order to meet the project's energy requirements, according to the government. For the expansion of Indian industry, coal is the single most important input. It is the primary driver of the Indian energy situation. Out of India's four primary fuel sources—oil, natural gas, coal, and uranium—coal accounts for the largest domestic reserve base and the majority of the country's energy production. Which method of coal mining is most cost-effective depends on the depth and quality of the coal seams, among other things.

Open-pit and underground mining are the two main methods. The depth of burial, weight of the overburden, and thickness of the coal seam are the main factors that influence the mining method selection. Coal seams less than 50 metres below the surface are commonly mined using surface mining techniques. Coal is normally mined underground, while surface mining techniques are occasionally an option when it is discovered more than 50 metres beneath the surface. For instance, certain mines that contain coal exist at depths greater than 60 metres and are mined using open pit methods due to the seam's thickness of 20 to 30 metres. Coal that is located below 100 metres is often mined deep. India uses more coal than either China or Japan.

2. STRATA CONTROL TECHNOLOGY

The strata control involves employing a variety of techniques to prevent or manage stratum failure around mine openings, at least during the time when access is required. This period might be for the duration of the mine like when the main mine is accessed from the surface, or it could be for a short amount of time, such when a continuous miner is lifted off a coal pillar. In all of its possible forms, from a material with great strength to one that has been extensively weathered, has very little strength, and resembles almost soil, rock is referred to as strata. Strata control refers to the methods employed to lessen the dangers.

In some cases, pillars are designed to yield or at least partially fail in order to lessen the strain on neighbouring highways. During second working with continuous miners, remaining pillars or stooks may only be designed to be stable for a very short time before being allowed to inevitably crumble. A tall, thin pillar is more likely to collapse than one that is short and fat, therefore the height to width ratio is just as significant in terms of pillar stability as the plan area. Therefore, the length and/or width required for a secure pillar will increase as the working height does.

The term "strata control" refers to managing the strata in order to maintain stability at the mine entrances underground, where operations will be taking place. Strata control within the goaf is normally of no importance, despite the fact that the need for stratum management may occasionally extend there, effectively to the goaf boundary. For stratum responses analysis, it is necessary to know specifics regarding the anticipated stress fields that the strata will be exposed to as well as characteristics like strength, elastic modulus, Poisson's ratio, etc. Its value is estimated with overly cautious designs if they are unknown or hard to measure, which could have unfavourable impacts. A basic understanding of any relevant geological features is also required. Dimensions and layout of my design.

The dimensions and shape of the mine design

- Mining direction-related aspects of mine design
- External support given in exchange for sacrifice
- Reusable outside of stratum support
- Reinforcement of strata
- Keeping failed stratum in place

3. STRATA MECHANISM

Stress is redistributed around openings created by underground excavations in rock. The rock moves into the aperture to adjust itself based on the strength and deformation behaviour. Low shear strength and low tensile strength are characteristics of sedimentary rocks that are normal to the bedding plane. In any location, unfavourable geological conditions could further weaken the total strength of the rock mass. Since gravitational forces cause the roof to deform as an added benefit, they are susceptible to failure. It takes prompt and appropriate assistance to keep a roof from collapsing. Stratified strata, such as coal measure rocks, bed separation, and subsequent roof slumping, have an impact on the immediate roof. The solid pillar's two sides get an equal distribution of the weight that the coal originally supported.

4. FIELD ASSESSMENTS

For the bulk of field tests, the force profile along the bolt is monitored in order to compile a thorough load transfer history throughout all mining phases and to evaluate the efficacy of the roof bolts. The instrumented bolt and the pull-out test are two essential tools for assessing changes in bolt load and investigating rock-support interaction in the field. Pull-out tests are routinely performed to assess a bolt's capacity to withstand a downward force.

The pull-out test is considered to be a pertinent test for the fully grouted roof in order to assess the bonding strength between the bolt, resin, and hole. The tested bolt is installed in the bolt using the same method and supplies as those used for the application. Franklin and Woodfield examined the pull-out strength of polyester resin anchors implanted in a variety of rock types with varied strengths, such as granite, coal, limestone, chalk, etc., in 1971. They determined the following relationship between the required bond length and rock type in order to adjust the strength of the resin anchor to the strength of the rock by using varying volumes of resin: (BFL) + SF = BL.

Where BF is the bond factor that can be calculated from the figure, BL is the length of bond required to provide less than 5% anchor failures at the design load, L is the required anchor strength, SF is the safety factor, which is 6 inches in strong rock and 12 inches in weal rock. if the overall stress (as determined by field measurements) exceeds the maximum permitted stress. The three techniques listed below can be used singly or in combination to lessen the stress in the bolt.

5. STRATA MONITORING INSTRUMENTS

DUAL HEIGHT TELE TALES:

Dual tell tales gives visual indication of roof dilation (movement). It is installed to at least two times of height of bolt length installed at mid pillar. It is installed at every junction and also installed at areas of known or suspected in stability.

Figure:1Dual height tell tales

ACTION LEVELS:

GREEN	0 – 25 mm
YELLOW	25- 50 mm
RED	50-75 mm

Table:1 Action levels of Dual height tell tales

- ❖ Green indicates that no action is necessary; carry on with usual monitoring.
- ❖ The colour yellow denotes that you should tell your supervisor right away and follow the rock bolt coordinator's instructions.
- ❖ The colour red denotes an immediate restriction on access.

If you see any Tell Tale in yellow sector inform your supervisor. If you see any Tell Tale in red sector withdraw from area and inform your supervisor.

ROTARY TELL TALE:

A rotating design with a 1 mm resolution has been created. At locations where roof deformation levels are typically low, this accuracy is crucial.

Figure:2Rotary Tell Tale

ACTION LEVELS:

GREEN	0-5 mm
YELLOW	5-10 mm
RED	10 mm+

Table:2 Action levels of Rotary Tell Tale

- Green coloration means that routine monitoring can continue unaffected.
- Yellow coloration denotes the addition of more reinforcement. Length and type of support to be determined by investigations coordinated by shift boss/mine overseer/roof control officer.

Red means that access is restricted.

AUTO WARNING TELE TALE:

Automatic Single Height Warning Tell-tale has the same action levels as the rotary tell-tale and was created specifically for India to provide additional instantaneous warning of movement occurring in a rock bolted extraction zone. This is especially useful in active mining conditions like pillar extraction operations, where personnel and equipment are working in close proximity to a growing goaf. When the indicator reveals more than 5mm of roof deformation, the LED is programmed to flash. The trigger level on the indicator is factory-set, but the user can change it if design monitoring suggests a different level would be more appropriate.

Automatic single-height warning The Tell Tale has the same action levels as the rotating Tell Tales and was created specifically for India to provide additional rapid warning of movement occurring in a rock bolted extraction zone. In circumstances involving dynamic mining, this is especially useful.

Figure:3 Auto warning Tell Tale

Figure:4 Roof Bolting Installed at South Indian Mine

Figure:5 Tell Tale Installed at South Indian Mine

- To give a visual warning that there is a risk of goafing in the vicinity of the telltale adjacent to the goaf edge.
- To give additional information to the CM operator as to whether to continue slicing, or to leave fenders to provide local support to enable the safe withdrawal of CM in a timely manner.
- To be installed in all junctions (3 and 4 day) with an anchor height of 10m

POSITION OF AUTO WARNING TELLTALES

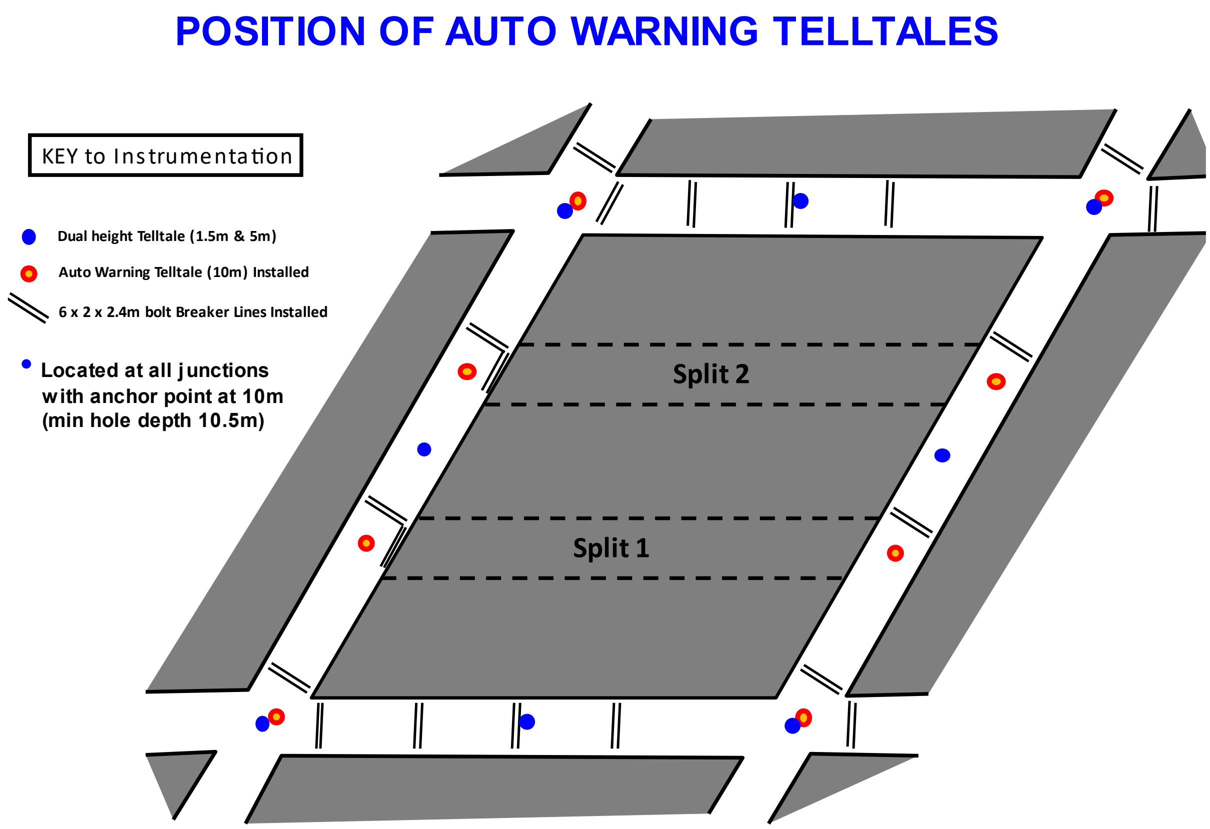


Figure:6 Position of Auto Warning Tell Tale

6. CONTROLLING THE DESIGN:

The aim of the controlling the designs to:

- To confirm Full pillar extraction method is appropriate for the mining conditions in by measuring:
- Amount of stress being taken by the pillars during extraction
- Pillar Loading in the Front abutment zone
- Stress transfer to barrier pillars
- Behaviour of roof and pillar ribs on retreat
- Remote reading **V**ibrating **W**ire stress cells in yield pillars and barrier pillars
- Remote reading roof extensometers

- Remote reading rib extensometers
- Strain gauged bolts (breaker lines)

7. STRATA MONITORING AND INSTRUMENTATION PLAN

Strata monitoring with the help of a suite of geo-technical instruments is very essential during the application of "Split & Slices" caving method of extraction with CM technology in the proposed panel CMP-9. The following geo-technical instruments can be used to monitor the strata behavior during depillaring of proposed two subpanels of CMP-9 in south Indian mine.

1) **Borehole extensometers:**

Eight 4-anchored borehole extensometers are proposed to be installed in total at strategic four-way junctions of the proposed panel CMP-9 (Subpanels CMP-9A (1) and CMP-9A (2), three in CMP-9A(1) and five in CMP-9A(2), keeping in mind the anticipated major and main fall). This instrument can be used to monitor the bed separation at four anchored layers at 1.5 m, 5 m, 10 m, and 15 m from the roof level in the upper strata

2) **Stress meters:**

In order to measure the developed vertical stress over the stress meters caused by the extraction of the pillar, it is recommended that 10 vibrating wire stress meters be installed in the panel CMP-9, of which 3 will be installed in CMP-9A (1) and 5 will be installed in CMP-9A(2). Additionally, two stress meters should be installed in the inter-panel barriers between sub panel CMP-9A(1) and CMP-9A(2). This will make it easier to keep track of how these pillars, stooks, and snooks are doing while being extracted.

3) **Rotary tell-tale:**

Monitoring the bed separation below and in the middle of the level galleries is another application for this sensor. For panels CMP-9A (1) and CMP-9A, depict the planned location of this instrument (2). visible layer advancement with an anchoring layer. Generally, the middle of the divided galleries are proposed.

4) **Auto warning tell-tale:**

Automatic alert For each pillar, a tell-tale can be set in the middle of a three-way and a four-way intersection at the location of anticipated large and main falls, additional auto warning devices may be installed.

5) Policeman props: You can install policeman props against each breaker line and goaf edge support. In order to warn the face working staff of oncoming stratum pressure on the goaf edge support and on the face, this will serve as a warning mechanism.

Fig. :7Proposed Instrumentation plan for CMP-9A(1) sub-panel

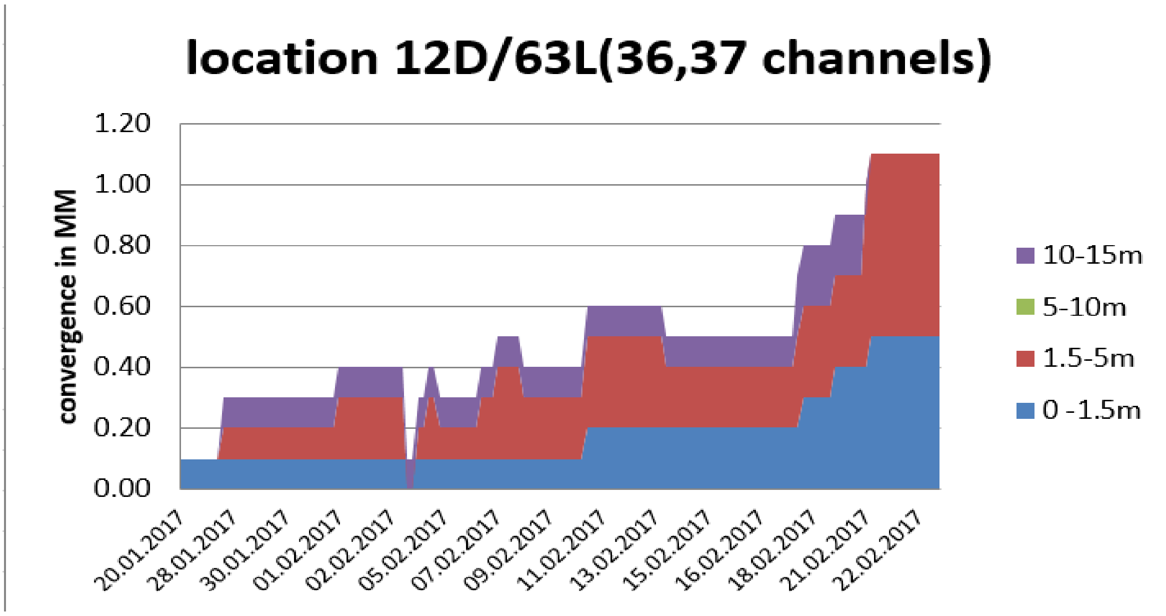


Fig. :8 Convergence recorded Location(12D/63L)

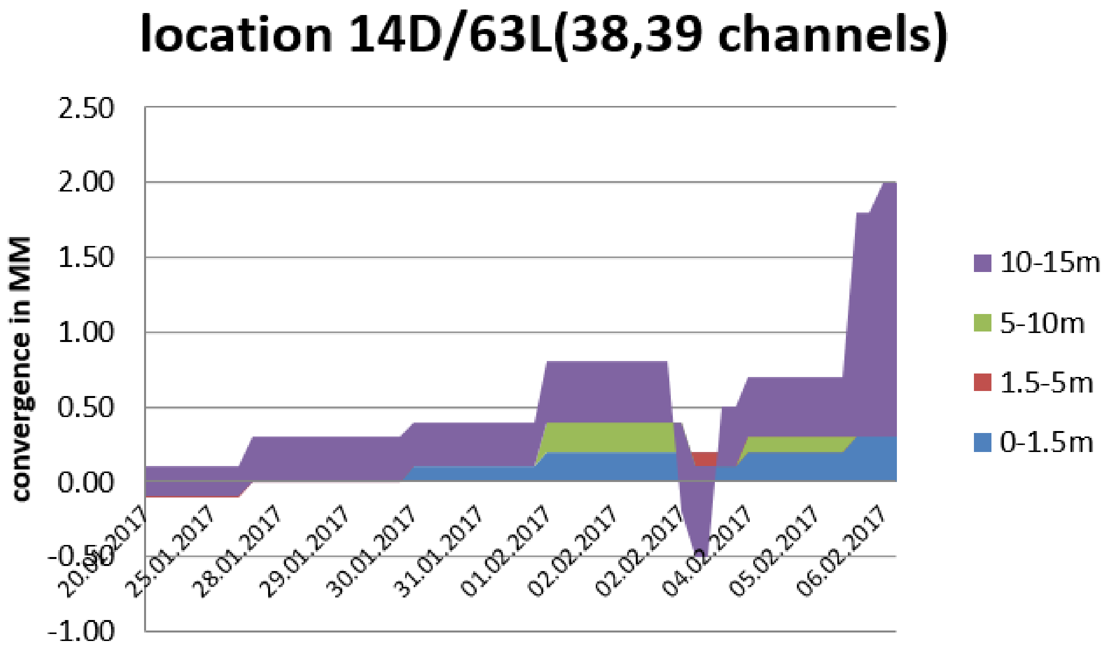
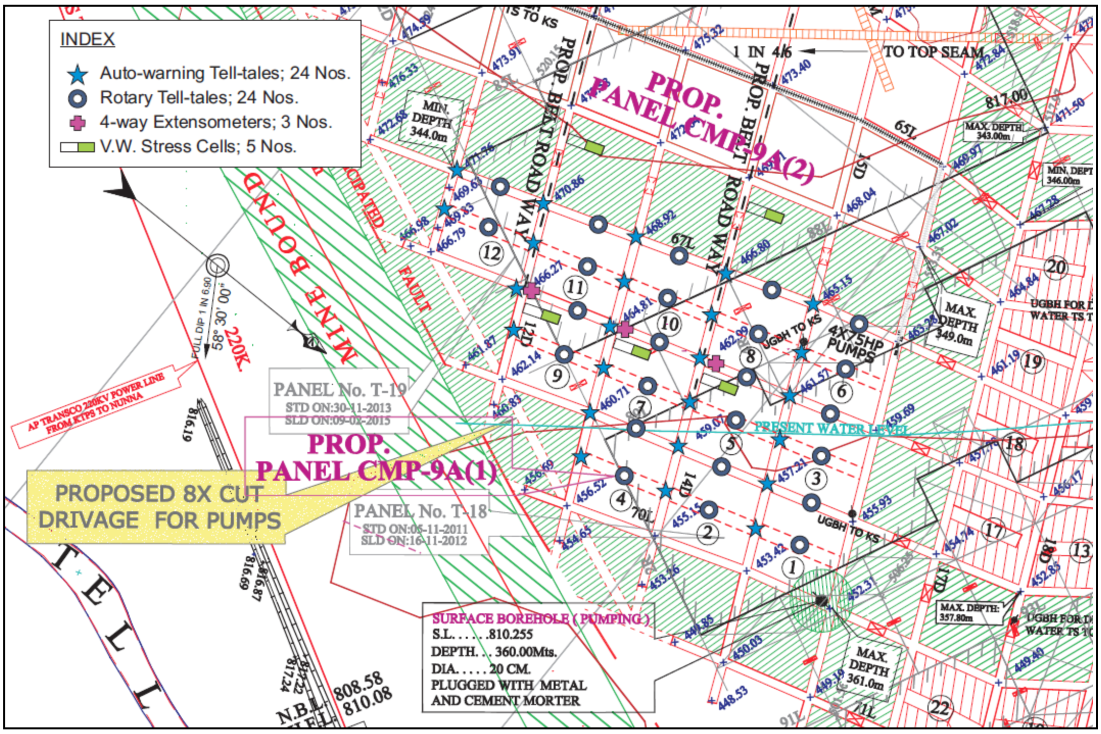


Fig. :9Convergence recorded Location(14D/63L)



8. CONCLUSIONS

- Installation & Monitoring of the instruments in Proposed CMP-9A (2) & CMP-9A (3) Panels
    - Preemptive corrections during extraction.
    - Design measurements for future caving panels while keeping safety in mind and striving to increase reserve recovery.

- Strata monitoring during extraction of CMP-9A (2) & CMP-9A (3) panels. Installation, monitoring, analysis and interpretation of field data.
- A Rock Bolting Engineer (RBE) holding 1st Class Mine Manager's Certificate (FMMC) assisted by trained persons will be associated with the experts for installation & monitoring of instruments during extraction of proposed panels.
- Training will be given to adequate no. of manpower for installation & monitoring of instruments and collection & entering of field data in a bound paged book in each shift.
- Mine authorities will create and implement a strata management plan. All instrument measurements will be documented in a bound book of pages.

- The field data and set trigger levels for giving warning to front line officials/supervisors for taking appropriate action.

9. REFERENCES

1.Jayanthu S, 2007, importance of strata behaviour observations vis-à-vis experimental trials in underground mines, IME Journal, vol 46, no. 4, pp 32-39.

2. Kotaiah, D., Ravikiran, C. and Rakesh, M. 2023. Numerical Modelling of Underground Coal Pillar Stability for Developed and Depillaring Panels for a South Indian underground Coal Mine. Journal of Mines, Metals and Fuels. 71, 6 (Jul. 2023), 722–727.

3. Kotaiah, D. and Kiran, R. 2022. Numerical Analysis of High Wall and Dumps Slope Stability. Journal of Mines, Metals and Fuels. 70, 6 (Sep. 2022), 288–297

4. Kotaiah, Chitti Ravi Kiran, Gangadari Tharun - 2023- 2023/11/09 - An Investigation of Spontaneous Heating and Control of Fires in a Under Ground Coal Mine Segmented Area - Atlantis Press- 1377 – 1383

5. D.Kotaiah, Chitti Ravi Kiran."Network Security Key Areas of IoT and IIOT- with Connected Devices Privacy and Security", International Journal for Research in Applied Science and Engineering Technology (IJRASET) Page No: 2076-2082.

6. Mathur S.P., 2007, Underground Coal Mining A Challenge, Proc. Of National Seminar on Mining Technology-Present and Future 21-22 September 2007, Bhubaneswar.

7. S Jayanthu, B N Naik, P N Mallick and Dr M K Mishra, 2007, advanced geotechnical instrumentation for improving safety in underground mines, Proc. National Symposium on ENTMS2006, Bhubaneswar, 10-11 May, 2007.

8.Follington, IL and Huchinson, IN, 1993, Application of continuous monitoring to investigate the rock mass response to mechanised pillar extraction, Geotechnical instrumentation and Monitoring in open pit and Underground mining, Szwedzicicki (ed.), Balkema, Rotterdam, pp 169-174.

9.Mucho TP and Mark C, 1994, Determining horizontal stress direction using the stress mapping technique, 13th Conference on Ground Control in Mining, West Virginia, 2-4th Aug. '94, pp 277- 289.