International Journal of Applied Engineering & Technology

USE OF ELECTRONIC TALE TELL SYSTEM FOR CONTINUOUS MONITORING OF UNDERGROUND ROOF STRATA

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ABSTRACT
A roof fall hazard is still one of the major threats in the underground mining industry. Each such type of event always brings great risk to miners and causes serious interruptions in the process of rock excavation. In general, the possibility of roof fall hazard occurrence is directly related to the local geology, the presence of horizontal stresses as well as the type of excavation method and the efficacy of the utilized roof support. Due to the complexity of this process, it is important to continuously evaluate the roof fall risk, especially in long life-time places where a mining crew is often present. Within this article, a detailed review of the current methods of monitoring and evaluating roof fall risk. Based on the extensive literature survey, different types of devices were described, and their advantages and disadvantages were pointed out. Depending upon the nature of the working and surrounding rock mass, a variety of geo-technical instruments are, generally, deployed for vigilance. Selection of positions and installation of these instruments involve good understanding of behavior of the associated rock mass, but continuous monitoring of their observations becomes an important issue. Some of the observations of a data-logger based monitoring are proved to be very useful, but the involved financial constraints have restricted its large-scale application. If the working is influenced by barrier effect, left our pillars/fenders inside the goaf or by a geological structure. In this project we can describe the use/ benefit of electrical tale tell system for continuous monitoring of Underground roof strata.

Keywords- instrumentation; ground control; roof fall hazard; monitoring systems; rock mass;

I] INTRODUCTION

An improvement in percentage of extraction during underground mining of coal brings the challenging issues of strata control. It is difficult to predict the behavior of the rock mass by usual means like manual field monitoring and numerical modelling. Different efforts made by theoretical assumptions and modelling do not generate valuable and reliable results. It happened so because the actual rock mass behavior is completely different from the usual assumptions. This is the reason why most of the strata-based formulations are empirical. Here, it is required to have an assessment of performance of different associated mining structures i.e. pillar, roof strata and applied support in the field. Any such performance evaluation in the field involves a number of measurements through underground instrumentation and monitoring.

As per the recommendations of 11th conference on Safety in Mines held on 4th & 5th July, 2013 at New Delhi, India. - In every Coal mining company, strata control cell shall be established at corporate and area levels within a period of one year, to assist mine managers, for formulation of Systematic Support Rules, monitoring strata control measure in a scientific way to ensure efficiency of support system and for procurement/supply of quality supporting materials. Risk assessment exercise shall be carried out in the mines for assessing for risk from the hazards of roof and sides falls and identifying the control mechanism with specific responsibility for implementation. This exercise shall be reviewed at regular intervals not exceeding a year. Every mine should employ a sound risk analysis process, should conduct a risk assessment, and should develop a safety management plan to address the significant hazards identified by the analysis / assessment.

Mustanir Ali (2014), described Strata monitoring Instruments, which typically measure the strata movement. They are low cost and installed at frequent intervals. They are commonly installed to monitor the roof near working faces, along travelling roadways and at other places frequented by workmen. They are there to warn mine workers about the danger. As such they are designed to show strata movement on a clear and easy to interpret scale of measurement, accurate to at least 1 mm. Analyzed collectively they can provide data for design verification. Safety and design of monitoring equipment forms an important part of efficient, cost-effective rock bolted roof support systems in underground coal mines.

David Conover, Tim Ross and David Bigby (2010) compared the results of strata monitoring by manual and automated instruments. Extensive arrays of tell-tale roof monitoring instruments were installed in a Mexican copper mine and a large underground mined storage facility in the eastern U.S. The data were used to evaluate roof stability during development and retreat mining and after installation of supplemental supports. The response of tell-tale in relation to known events affecting roof stability, including nearby pillar extraction, roof caving, and installation of supplemental cable bolts and separation of the immediate roof layer was studied. The strategy for processing the large quantity of data, presenting the data for review, monitoring the system remotely, and identifying and reporting critical events was described.

Anthony T. Iannacchione, T.S. Bajpayee and John L. Edwards (2006), examined the potential for monitoring micro seismic emissions activity as a means of forecasting roof falls. There has been a persistent need to forecast roof falls, so that miner's exposure to hazardous underground environments can be minimized. Several monitoring techniques have been developed and are used today with varying levels of acceptance in the mining industry. The micro seismic activity collected from Moonee Colliery demonstrates that techniques to forecast roof

rock instabilities in underground mines are possible. T. S. Bajpayee, A. T. Iannacchione, NIOSH and S. R. Schilling (2008) described a case study where a surface-based microseismic system, using triaxial geophones in boreholes drilled from the surface, was deployed at a large limestone mine for detecting strata fracturing and roof failures. It detected the first rock fracture event 17 minutes before the rock fall event. The geophone array was sensitive enough to identify all large rock fracture, impact, and blast events as well as medium-size rock fracture events occurring close to the geophone array.

Razani, Chamzini and Yakhchali (2013) applied Fuzzy inference system (FIS) to predict roof fall rate more in accurate, precise, and sure way for controlling, mitigating, and/or even eliminating the risk of roof fall. A technical report by McDonnell and Haramy (1988) states that, if mine operators can locate high-stress and potentially burst-prone zones, they can then use stress-relief methods to control the burst condition. One method of locating the high-stress zone is the probe-hole-drilling or drilling-yield method. Singh Rajendra, Singh A. K., Mandal, Singh M.K. and Sinha, 2004 done assessment of stress level by instrumentation and monitoring of strata movement during underground coal mining. They concluded that the hostile impact of these stresses can be managed effectively by instrumentation and monitoring of strata control parameters. Mark K. Larson, Douglas R. Tesarik, J. Brad Seymour and Richard Rains (2000) described different types of geotechnical instruments in underground mines to study ground control problems and develop means of reducing accidents and fatalities caused by ground falls. The advantages and disadvantages of various sensor technologies, various instruments, sensors, and data acquisition equipment that have been used for studies were explained. The practical recommendations regarding the use of specific instruments and data acquisition systems were provided. The general approach to the design and implementation of a successful instrumentation plan was also outlined.

R. R. Yerpude and Deepak V.Walke (2014) investigated in to the factors affecting roof fall risk in an underground coal mine. During investigation, the real time developments in roof instability before actual occurrence of roof fall was assessed with the day to day observations of strata monitoring instruments like tell-tale, glass bearing plate and rigid convergence recorders. Aveek Mangal (2013) described Support resistance as the most promising and effective scientific

tool to predict various aspects related to strata mechanics of Longwall mechanized workings. The characterization and understanding of geo-mechanics of longwall strata is very important for determining support requirement and planning and design of panel layout so as to ensure safety, stability and higher productivity. To understand actual fracture zones, fracture propagations and failure mechanisms of the longwall face, the geo-technical field investigation with various forms of field measurements techniques have been carried out using instruments like stress capsules, extensometers, convergence measurement devices, subsidence surveys, borehole camera, observation of water loss in experimental boreholes etc. He used observations of the strata monitoring instruments as one of the inputs for development of software to estimate the required support resistance.

With conventional free-standing support such as props, there is obvious indication when they are carrying excessive load, the greater the load the greater the deformation. Roof bolts however give no visual indication of load increase and therefore no indication of how close either the individual bolts or the system is to ultimate failure tale tell multi spring wire extensometer will detect any unstable trends in the strata so that timely remedial action can be taken by the management.

Tell tale is strata – extensometer. It provides pre-emptive warning of roof-falling. The dual-height tell tale provides an immediate visible warning, distinguishing between movement above and below rock-bolted height. It was first developed by British Coal in early 1990's. Subsequent to that many permutations and improvements in the basic design has been developed to suit different mining conditions.

II] OBJECTIVE

Here there are some objectives that we are going to give a brief explanation regarding the underground mine ventilation in which we are taking increasing quality of ventilation system as our main objective or motive and the following objectives that we are going to addresses are:

To study the issue of underground roof strata monitoring

1. To study different type of electronic tale tells instruments and installation process in mines.
2. To study about uses of electronic tale tell instruments system for continuous monitoring of the roof strata

III] ISSUE OF UNDERGROUND MEASUREMENT

Formulation of norms for the design of underground mining structures involves measurements of different strata control parameters during excavation under varying conditions of different sites. But it is practically impossible to be continuous in space for an underground environment. Geological , technical and operational factors bring a number of threats for the safety of the applied instrument for an underground investigation. However, on the basis of field of experience of strata control monitoring at different coal fields of the experience of strata control monitoring at different coal fields of the country, following factors need special attention at the planning and instrument selection stage of the monitoring:

1. Underground environment
2. Depth cover
3. Characteristic of roof rock mass
4. Dimension of excavation

3.1 Underground Environment

Heat, humidity, visibility, danger of roof and side falls and space constraints of underground working influence the selection of instruments to be used for monitoring. An environment like a surface facilitates a number of available instruments which can provide information continuously in space and time. But, due to unfavorable conditions of an underground mine, only mechanical and electro-magnetic instruments suit this application. Mechanical instruments are non-remote type and, here, the observations are taken manually as the applied instruments are supposed to be directly accessible. Once the instrumented area becomes inaccessible, scope of the study only remains with the electro-magnetic instruments. Moreover, the electronic instruments are supposed to be intrinsically safe, portable and robust to face the rough and gaseous working environment of the underground. It is a data taking device i.e. resulting in the issue of intrinsic safety. This problem of electrical/ electronic hazard can be tackled through selection of a suitable instrument, whose data can easily be transmitted to a remotely located safe place of the readout.

3.2 Depth Cover

The governing rock engineering norms of underground mining at shallow cover are different from those at deeper cover. It is worth mentioning here that, generally, the stability of excavations close to the surface is mainly controlled by rock structure while the stability of deeper excavations is more influenced by the properties of intact rock and pre-existing stresses. The variation of in situ stress field with depth cover was well experienced by the mining engineers even before advent of the modern in situ stress concept. This is the reason for the age-old concept of increase in pillar size with depth cover, which is a well familiar example of practical understanding of the importance of depth cover of underground coal mining. Depth cover has significant impact on the in situ stress condition, depositional compactness and geo-physical properties of rocks. Therefore, the depth cover affects response of underground structures during strata equilibrium dynamics of the mining, which ultimately, influences the nature of the strata monitoring instruments. Depth cover even directly influences the type of instruments to be deployed during underground mining. For example, if the work is taking place at shallow cover, then a borehole extensometer from the surface can be installed to visualise the horizon of parting/ caving above the underground void. The study of bed separation through a borehole extensometer is extremely difficult for a deeper mine.

3.3 Characteristics of roof rock mass

The behaviour of overlying roof rock mass influences the face condition of an underground mine. For an easily caveable roof strata, the goaf gets packed quite frequently during face advance. Here the bulking factor of caved material is important and the face is unlikely to experience dynamic loading. Generally, load on support, bed separation and roof to floor convergence are the parameters of interest during working below such easily caveable roof strata. A working face experiences large overhang if the roof strata are massive in nature. Under this condition, stress meters may play an important role to visualise nature and extent of dynamic loading during enmasse movement of the roof strata. A careful monitoring of mining induced stress development may help in estimating the time and period of occurrence of the dynamic loading. Results of field monitoring of mining induced stresses (vertical) at two different sites are presented in fig to show the influence of overlaying roof strata on nature and amount of the stresses. Fig (a) shows variation of the mining induced stress for depillaring under an easily caveable and softer overlying roof strata. Fig. (b) represents variation of mining induced stress over a pillar for depillaring under a massive and strong sandstone roof strata. Thus the strata control parameters get affected by the competency of overlying roof strata.

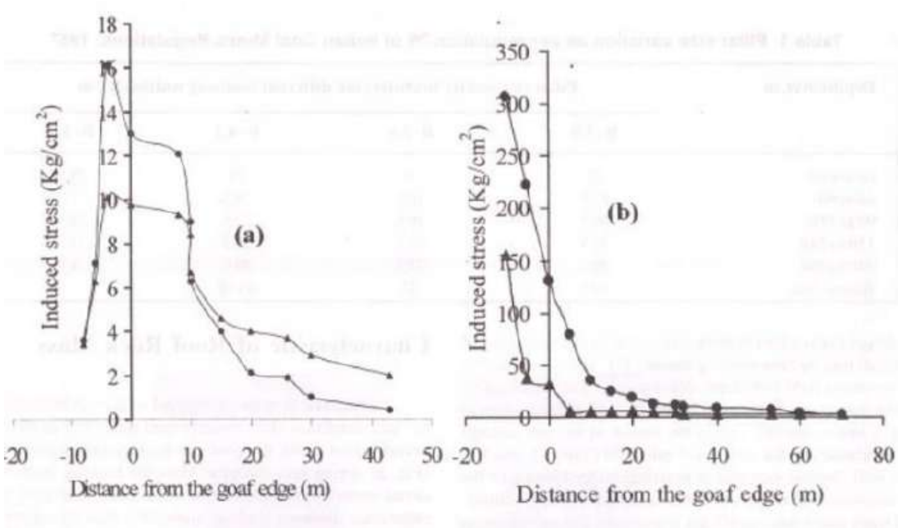

Fig. 5 : Variation of mining induced stress (vertical) with face advance for two different overlying roof strata conditions.

3.4 Dimension of extraction

Percentage of coal extraction remained low during initial development of a coal seam for room and pillar working. Stability of the roof span over the development galleries limits the width of the room. Depending upon the competency of the roof strata, width of the development galleries is varied at different sites to suit the operational requirement of the mining. The stability of these freshly exposed galleries is monitored through underground instrumentation. Here, observation of load on support and roof to floor convergence may provide a fair idea about the stability of the roof strata. The increase in dimension of excavation increases the percentage of extraction, which ultimately affects the stability of the underground structures like rooms and pillars. We start with rooms and pillars, which are designed for long term stability and here simple instruments like telescopic convergence indicator and load cells are adequate to visualise the stability. However, for a medium stable structure like applied supports around the working, bit more sophisticated instruments like instrumented bolts and borehole extensometers are required. Stress meter and remote convergence indicators are used to assess the performance of a short -term stable structure like slice/rib, which are formed at the final stage of the extraction.

IV] STRATA MONITORING INSTRUMENTS

Optimization of safety and recovery during coal mining involves a number of measurements through instrumentation and monitoring. Rajendra Singh, A.K. Singh, P.K. Mandal, M.K. Singh & Amalendu Sinha (2004) stated that the hostile impact of the highly active nature of mining induced stress development over the natural support under a hard and massive rock can be tackled through effective underground instrumentation and monitoring strata control parameters. Prediction of strata behavior by theoretical analysis becomes unreliable due to almost impossibility of simulation of the real field conditions in mathematical, physical or numerical models. Thus, S Jayanthu (2011) stated that the empirical formulation, based on in-situ measurements of strata behavior parameters, is an accepted way to estimate the strata behavior. There is a need to be more innovative in application of the existing instrumentation with proper planning by experienced strata control engineers which may lead to possibility of modification in existing practices for better safety and economy of mining ventures. The real time developments in roof instability before actual occurrence of roof fall was assessed with the day to day observations of strata monitoring instruments. The convergence recording at selected sights was done with the following instruments: -

3.1 Tell-tale

It is the simplest mechanical device consisting of a strata movement indicator positioned in the mouth of a drilled hole and attached to an anchor installed up to the hole. It provides preemptive warning of roof-falling by detecting any unstable trends in the strata by estimation of bed separation in the roof so that timely remedial action can be taken.

3.1.1 SINGLE HEIGHT TELL TALE

It comprises a strata movement indicator usually with color bands and/or graduations. At its simplest a mechanical tell tale consists of a strata movement indicator positioned in the mouth of a drilled hole and attached to an anchor installed up the hole. The earliest tell tale were simply longer bolts, points anchored above the support bolt horizon, and left protruding from the roof to indicate movement within the bolted horizon. These suffered from the disadvantages of limited monitored height and false readings caused by roof shear, which can result in the tell tale bolt being trapped along its length and pulled down with the roof. A typical single height tell tale now consists of a reference tube, an indicator tube, a stainless steel wire and a spring anchor positioned at twice the bolted height as shown in figure 1.

FIG - 1

3.1.2 DUAL HEIGHT TELL TALE

Dual Height tell tale is designed to be installed for monitoring the bolted strata. They have two versions – one for dry drill holes and the other for watery drill holes. This is designed to be installed following the installation of roof bolt reinforcement. The general assembly is shown is figure 2

3.1.2.1 Installation

1. Drill hole, using appropriate bit, to at least twice the bolt length.
2. Insert top anchor, attached to smallest indicator 'B', to top of hole. Used purpose-designed insertion rods graduated to confirm anchor position. Check for firm anchorage.
3. Insert lower anchor attached to larger indicator 'A', 0.3 m below the top of the reinforcement height using purpose graduated insertion rods.
4. Secure reference tube.
5. Position indicator 'A', top of green band to be level with bottom of reference tube. Align to scale. Crimp ferrule in position.
6. Position indicator 'B', top of green band to be level with bottom of indicator 'A'. Align to scale. Crimp ferrule in position.
7. Record details: At all tell-tale sites a sign must be placed bearing a unique reference code for identification purpose giving the type of tell-tale, its position, date and time of installation and anchor height. This information should be passed to relevant officials, eg the safety officer or manager.

FIG.2

3.1.2.2 Reading methods

1. By color Report whole and part bands visible e.g.

'A’: Green Yellow, Red

'B’: 3/4 Green Yellow, Red

2. By Scale Report measurement, in millimeters, lining up with reference marks for each anchor. Reference for 'A' is at the bottom of the reference tube. Reference for 'B' is at the bottom of indicator 'A'. Scale has millimeter divisions, with centimeter marks

3.1.2.3 Interpretation

1. Movement of 'A' relative to its reference (bottom of reference tube) is equal to the strata expansion within the bolted reinforcement height.
2. Movement of 'B' relative to its reference (bottom of 'A') is equal to the strata expansion at the top of bolt reinforcement height.
3. The total strata expansion is 'A' plus 'B'. 4 Expansion of strata above the top is not detected.

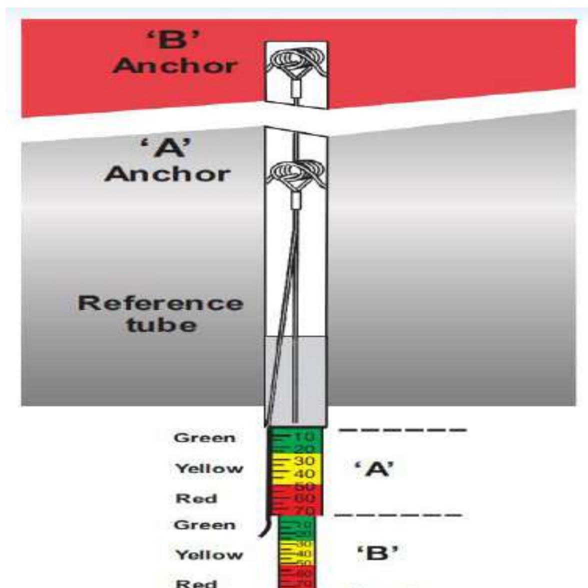

Fig.4

Dual height tell-tale general assembly

3.1.3 THREE POINT TELL TALE

It is an improvement on this basic design of dual height tell tale. It is advocated where a combination of roof bolts and long tendons are installed at the face. Since the adoption of the mechanical tell tale, many permutations and improvements on the basic design have been developed and applied to suit different mining circumstances. The triple height tell tale (fig 6) has been developed where 1-8m full column bolts and long tendon bolts of 3.6m are used. As its name suggests, the triple height tell tale has an additional concentric indicator when compared to the dual height tell tale. The A indicator (nearest roof) is anchored 0.3m below the top of the rock bolts, the B indicator (middle) is anchored 0.5m below the top of the longer bolts and the C indicator (lowest) is anchored a minimum of 5m above the roof horizon or 1m above the longer bolt. This allows the mine personnel and particularly the support engineer to easily determine whether any measured roof dilation is occurring within the bolted height (A indicator), in the roof zone reinforced by longer bolts alone (B indicator) or above the reinforced height (C indicator) and hence allows the most appropriate type of remedial support to be applied where required.

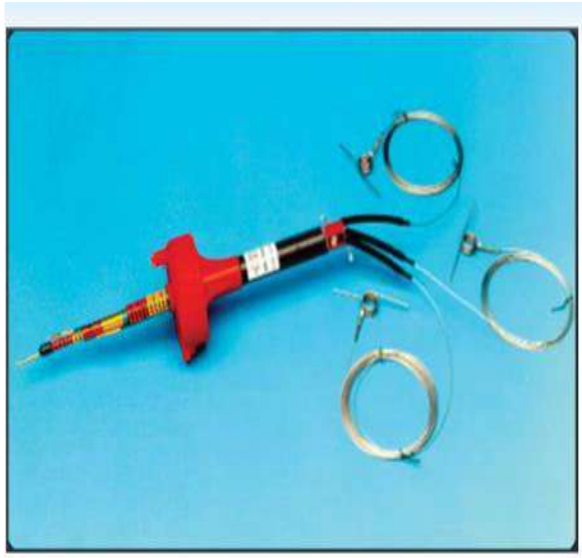

FIG.6

3.1.4 FOUR POINT TELL TALE

It is a general purpose four wire extensometer, incorporating a water diverting feature and easily read visual indicators. The indicators are 150mm long and graduated in millimeters, with a centimeter scale. The range of the instrument is defined by the length of each indicator and the travel available (150mm maximum). The system is designed for installation in vertical up-holes and employs gravity for wire tensioning as shown in fig. 7

FIG.7

3.1.5 ROTARY TELL TALE

Mechanical tales installed in the roadways are difficult to read where the height is more. This problem has been overcome for single height tells tales by developing the rotary tell tale. The device converts roof movement into rotation of a pointer round a dial and magnifies the movement by a factor of fifteen. It is easy to read, easy to install, accuracy is better than 1mm and is of low cost. Small movement can be read easily with the reading visible from below even in a 5 meter high road way. The dial face is sub divided into colored bands corresponding to chosen action levels. (Fig. 8)

3.1.5.1 Installation

1. Drill hole using 43mm bit to the required height.
2. Insert anchor of suspension cable to top of hole. Use graduated purpose Insertion Rods to confirm anchor position. Tug wire to seat anchor.
3. Keeping the suspension cable under tension, the reference tube can now be inserted into the bottom of the hole. The reference tube should be pushed fully into the hole.
4. Position tube fitted with indicator to the lowest point and crimp ferrule.
5. Rotate and loosen positioning nut, rotate 12 sided scale disc and align pointer to zero mark on the scale.
6. Tighten positioning nut.
7. Now the extension meter is ready for working. Movement of roof will be transferred to reference tube. Pointer position on scale will indicate the strata expansion in mm.

Green zone: 0 - 5 mm

Yellow zone: 6 - 10 mm

Red zone: 11 - 25 mm

FIG.8

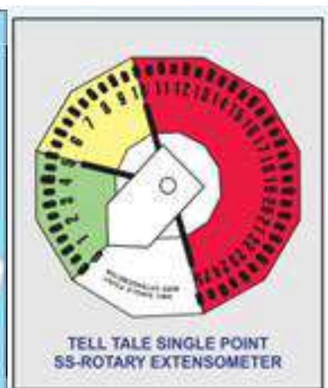

FIG.9

3.1.6 AUTO WARNING TELL TALE

This provides a warning of impending goafing in de-pillaring operations via high visibility flashing LED's. Intended applications include pillar extraction areas in the room and pillar workings to give warning of impending goafing. It has the potentiality of saving many miners lives during depillaring operations. This is based on the premise that goafing events are recorded by smaller scale roof dilation which will be detected by the tell tale. The tell tale design includes a low volt alkaline primary cell supply and LED configuration housed within the existing telltale's plastic drip tray molding. The auto warning electronic module powers the LEDs in a flashing sequence when a preset level of telltale movement is reached. A minimum of two LED's are employed. The flasher module has an operational

'flashing' life of over a week. The auto warning tell tale (Fig - 10) is currently being used in the first fully mechanized pillar extraction bord and pillar mines in ECL, SECL, WCL & SCCL.

Telltales are being installed in each junction and roadway midpoint prior to extraction operations. The telltales used are single height types with the anchor position at 10m into the roof and a trigger level of 5mm. This combination of large monitored height and low trigger level is intended to ensure that the tell tale warning is triggered prior to a major golfing event.

FIG.10

3.1.6.1. Installation

1. Drill hole using 43mm bit to the required height.
2. Pre set the auto warning tell tale to the desired scale where auto warning is to trigger.
3. Insert anchor of suspension cable to top of hole. Use graduated purpose Insertion Rods to confirm anchor position. Tug wire to seat anchor.
4. Keeping the suspension cable under tension, the reference tube can now be inserted into the bottom of the hole. The reference tube should be pushed fully into the hole. Fig. 11
5. Position tube fitted with indicator to the lowest point and crimp ferrule.
6. Now the extension meter is ready for working. Movement of roof will be transferred to reference tube. When the roof movement reaches the preset scale auto warning led will glow and start blinking.

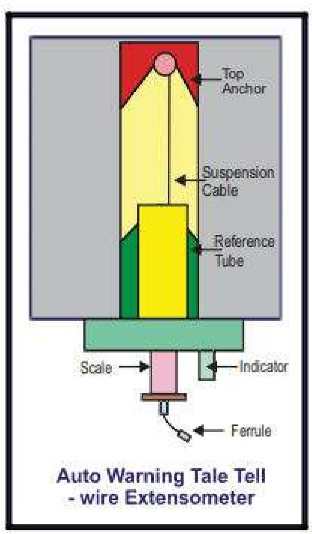

FIG.11

The AWTT is currently being used in all mechanized depillaring operations in ECL, SECL, WCL and SCCL. There are two factors which are responsible for the performance of any instrument in underground coal mining which are underground mining environment and Characteristic of roof rock mass.

V] ELECTRIC TALE-TELL SYSTEM

The most common instrument mode used in mines, although mechanical systems still found widespread use in displacement monitoring. Electrical systems operate on one of three principles: electric resistance strain gauge, vibrating wire and self- inductance.

Tell-tales are a low cost, easily installed monitoring device which will provide a continuous visual indication of the roof conditions.

For monitoring by use of electric tale-tell system

1. Immediate roof convergence
2. Bed separation between layers
3. Progressive failure height of the strata
4. Ensure efficiency of bolting and influence of extraction or development.
5. Fixed only in the roof of the gallery
6. Manual reading of deformation
7. Maximum height can be fixed is 10 m or larger.

VI] CONCLUSION

Instrumentation is vital for the safety but it is highly challenging and technical to extract information from the readings of these instruments to project the strata behaviour during an underground coal mining. The use of telltale as an effective safety warning device requires procedures detailing how they should be deployed and read and specifying what action should be taken, depending upon the level of roof dilation measured. Movement above the rock bolted height is an important parameter, which can indicate that the bolt system is failing to provide effective support. A combination of different geo-technical instruments like stress meters, load cells, Instrumented bolt, extensometer, convergence indicator and electric tale -tell system may prove to be a better system for safety and efficiency of the MD PANEL. Tell-tales are a low cost , easily installed monitoring device which will provide a continuous visual indication of the roof conditions.

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