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Summary of Project Report: Demonstration and Proving of the Acoustic Energy Meter for Detecting Incompetent Mine Roof as Part of Routine Roof Sounding

Detachment of relatively small blocks of rock from the roof of coal mine roadways continues to be a significant safety hazard. In a risk management context, the hazard cannot generally be effectively predicted and defined prior to actual mining, due to the uncertain location of the instability. Furthermore, the hazard may not be readily apparent when the roof surface is exposed, as it may be involve hidden rock defects.

One risk mitigation strategy is to mesh over all exposed roof (and occasionally rib) surfaces, providing a hard barrier between the hazard and personnel. In the absence of a complete barrier, the hazard to some extent remains. Traditionally the first 0.5 m of roof has been tested by 'sounding' with a steel rod or bar. This method has often proven effective, but the results can be subjective. A hand-held instrument to provide a quantitative value or "roof stability index" has now been developed. Research done some 15 years ago in the UK during the introduction of segmental concrete linings into deep coal mines resulted in the development of the "Acoustic Energy Meter" (or AEM). This was developed to remotely identify voids behind concrete linings, where backfilling was incomplete.

The physical phenomenon utilised by the AEM is vibration decay rate (dampening) in a material. This characteristic was investigated by the CSIRO in the early 1990s and identified as a possible technique to remotely determine areas of potentially unstable or incompetent roof skin. It is a measurement of the rate at which impact energy is absorbed or dissipated by a body. It depends largely on the medium geometry and the material internal friction properties. In general, the bigger the body (ie the greater the amount of material) involved, the faster the energy is absorbed / dissipated. Also, when a body is vibrated, its natural rate of decay characteristics are insensitive to the initial energy input or differences in amplitude or frequency. Therefore, decay rate is more likely to be reproducible and a relatively consistent characteristic of a body.

The AEM utilises a geophone placed in contact with the medium (rock surface). The signal is rectified and amplified by the processing unit to produce the required output. It has automatic arming and reset functions and features a "traffic light" LED alarm display, as well as a digital readout. The rock is struck in a prescribed manner and a reading is illuminated on the digital display. A minimum of three readings is usually taken for each sample point and the results then averaged.

This project has demonstrated the potential uses of the instrument in Australian coal mines by providing details of:

i) recent successful work in South African coal mines,
ii) tunnelling applications in Europe,
iii) the fundamental operational basis of the AEM,

iv) site evaluations within the Australian coal mining industry and
v) site specific usage and calibration guidelines.

The AEM has undergone a significant amount of testing and evaluation in a variety of applications and geotechnical settings worldwide. The findings of this project were consistent with the overseas trials and experience. In particular, the AEM has proven capable of consistently and reliably identifying the presence of discontinuities / open partings within the lower 0.8m of the roof. This capability is highly significant, given that the majority of coal mine roof fall fatalities over the last 20 years have involved pieces of rock <0.4m thick. Therefore, a fast and effective instrument to detect open partings within this range could improve mine safety.

This project has also added to the AEM experience base by identifying a common range of readings for different lithologies (ie coal, claystone, siltstone, sandstone and conglomerate) and indicating types of rock (coal, laminated to thinly bedded material) where the range of AEM readings appears too broad and imprecise to specifically recognise open partings. Nonetheless, the instrument output can still be calibrated to overall ground conditions, thereby providing a general measure of roof behaviour that can be assessed statistically to determine regional trends within the mine.

This project has demonstrated that the device can play a valuable role in identifying potentially unstable blocks within the roof skin. The instrument removes much of the subjectivity from traditional roof sounding, by providing a repeatable value to relate to the local roof conditions. This information can be stored, updated and interrogated to identify longer-term trends, such as in areas of roof deterioration. This is of particular relevance to those mining operations that have extensive outbye areas of unmeshed roof and where long-term roof behaviour requires particular consideration (such as areas requiring rehabilitation for future use or areas containing relatively low levels of roof support or suspect, potentially corroded support).

The instrument also has considerable potential in other unlined tunnel environments, which in the coal mining context relates primarily to assessing rib behaviour trends, both at individual mine sites and in terms of a broader industry database. The device has already demonstrated a sensitivity to variations in rib behaviour associated with changing depth of cover.

The project has gained full intrinsically safe approval for AEM use in the hazardous zone of underground coal mines. Therefore, the instrument can now be used in both active development operations and as a tool for assessing existing outbye roadways.

Ultimately, the AEM simply provides operators with another tool to identify, monitor and remediate strata related hazards effectively. Where appropriate, the AEM would be used most effectively in the context of a formalised strata management process, applying the general guidelines for the instrument developed by this project.