Safety and health in mines research advisory board Annual review 2012

Contents

Introduction

The Safety and Health in Mines Research Advisory Board (SHMRAB) is one of the Health and Safety Executive's (HSE) advisory bodies. It is chaired by Her Majesty's Inspector of Mines and has members representing employers and employees in the British mining industry. Current members and others who contributed during 2012, are listed in Appendix 1[9]

Contact details for more information on the research houses and individual projects mentioned in this review can be found in Appendix 2[10].

[back to top]

Fire and explosion

Mine Fire Detector: Combined High-Sensitivity Smoke and NO_X/CO Sensors
In UK underground coalmines, fire alarms detect fewer fires than mine personnel, particularly during the early combustion stages. As collieries become more automated, there are fewer personnel to detect fires and, as drivages become longer, the time for evacuation is increased.

Two types of fire detector are principally used in UK coalmines based on products of combustion (FIDESCO) and carbon monoxide. However, FIDESCO is not user-friendly, susceptible to false alarms and is obsolete. Carbon monoxide sensors are used to detect spontaneous combustion and more developed fires but are relatively insensitive to smouldering conveyor belt fires, which are the predominant type.

Previous work tested has shown that an electronic nose "Samdetect", a gaseous products of combustion detector performed better for detecting underground fires than optical, high-sensitivity smoke detectors. The Samdetect uses a neural network to distinguish fire events based upon the outputs of six semiconductor gas sensors. Unfortunately, the manufacturers of the Samdetect (EADS/RST) have taken the commercial decision not to go ahead with development of a commercial model of their instrument to M1 or M2 certification for the present time.

Fire detection is also being investigated for non-coal mines where M1 or M2 certification is not required. Testing was carried out at Cleveland Potash Mine at Boulby to determine the effectiveness of Samdetect in that environment.

HSL continues to provide low-level support and independent technical advice to HSE on fire detection underground and to publish the previous work in a peer-reviewed journal.

The support includes assessing the Samdetect in non-coal mines, e.g. gypsum mines, where ATEX M1 certification is not required and which, due to its cost, prevented commercial development for underground coalmines; and considering other possibilities for fire detection in the UK coal mining industry including low-sensitivity optical smoke detectors or a reduced scale electronic nose or other lower cost multi-sensor systems. Further testing would be required (although as a separate project) in which the alternatives to the Samdetect could be properly assessed.

Minimising risk for and reducing impact of fire and explosion hazards in underground coal mines [Minfirex]
MINFIREX is aimed at developing strategies to prevent fires and explosions by developing innovative detection and fire fighting methods, especially for hidden fires. MINFIREX commenced in July 2010 and the Project partners include Mines Rescue Service Ltd and UK Coal.

As a part of the work aimed at identifying improved strategies for the prevention of fires and explosions, research into bio-degasification techniques to reduce explosion and spontaneous combustion fire risks is being undertaken. Methanotrophs are able to metabolise methane and are the focus of the first part of MRSL's research within this project. Previously, MRSL had identified the methylocystis strain of methanotroph as being the one with which to continue investigations. This is a naturally occurring strain in many underground coal mine locations. The recent research focussed on identifying optimal growth conditions of the methylocystis bacteria, by evaluating the effects of temperature, mineral salt content and

phosphate buffer (pH). Growth was assessed over the temperature range from 26° C.to 45° C, with maximum growth occurring at 37° C. Samples which had shown no growth during a period of incubation of 40 hours at 45° C rapidly returned to growth when the temperature was returned to 37° C, demonstrating that cells had not irreversibly inactivated. Mineral salt concentration had virtually no effect on growth rate. A maximum permissible phosphate buffer concentration was determined, which will enable optimisation of culture pH. Overall growth rates of around 0.13 h^{-1} were recorded during the trials - this equates to a doubling time of approximately 5-6 hours

The next phase of the research is to assess the likely effectiveness of using the methanotrophs in a simulated mining environment. A range of tests designed to provide estimates of methane absorption rates is currently being undertaken. These tests entail samples of goaf material being immersed in a 3% methane mixture.

In the second area of study in this project, MRSL and UK Coal have been examining the sampling of incombustible (IC) dust. As reported previously, there are no alternative approaches to the two on-line sampling instruments currently on the market for the measurement of IC dust which are either viable or practicable. Predictive techniques with on-line monitoring potentially offer the best solution.

A database of the IC content of roadways over a period of 18 years was reviewed, in order to identify trends and areas of concern. One purpose was to identify whether there were specific areas in the mine which were most likely to exhibit compliance (80%) failures. However, the variances present in the data indicate that locations within each mine either did not significantly influence reliability, or that the influence of these variables was being masked by other factors.

In the distribution of IC for all the failed samples recorded, very few failed in the 75% - 79% range. Within this range, the need for additional stone dusting may not be clearly visible. In these cases, using underground measuring instruments could potentially be of benefit, as they would assist in the identification of these small shortfalls in a more immediate manner. However, the vast majority of failures resulted in samples that were 10% or more below the required 80% IC standard. In these situations it is likely that the need for further stone dusting would be clearly visible by experienced mining personnel. There are harmonised standards that address the prevention and protection against explosions of settled coal dust within the EU, with statutory instruments in place to establish a common set of risk reduction and management measures. However, there is no legislative requirement for reporting and recording when an area has been stone dusted and how much stone dust had been used. Whilst in some cases daily inspection reports produced by underground officials mention that stone dusting operations have been carried out, there are no structured provisions in place to record this information.

Mine Road Dust Analysis call-off

HSL was asked to provide an analytical service for batches of 10-20 samples of dust collected by Mines Inspectors to determine Incombustible Matter (%IM) using a sample preparation and analysis method based on that described in IR/L/FT/90/03. During 2011-12 two batches were received and analysed and since April 2012 a further two batches have been received.

[back to top]

Mine environment

Development of novel technologies for predicting and combating gas outbursts and uncontrolled gas emissions in thick seam coal mining [CoGasOut]

The objective of this project is to develop and test novel technologies for the prediction and combating of gas outbursts and uncontrollable gas emissions in coal mines which operate in thick and/or steeply dipping thick seams, primarily in Slovenia and Spain. Imperial College is one of the other partners.

MRSL's research has two elements, one applying electromagnetic seam survey methods to determine the influence of stresses imposed by very high pressure entrapped methane and possibly mobilise the gasses, and secondly a study of protective barriers which may be used to protect face workers against sudden emissions.

As a further extension of the Chinese research reported previously to displace methane from coal, primarily by the application of high intensity electromagnetic fields to the coal sample, a development involving on-off keying of the E-field excitation was investigated, which has a number of advantages.

This is essentially an attempt to detect a "modulation" in the real time gas emission rate. By judicious selection of the frequency of on-off keying it should be possible to discriminate the modulation component for a wide range of gas emission/desorption rates from various coal types. This could ultimately permit classical signal processing techniques (frequency domain and time domain) to be applied in an automated measurement sequence.

A limited programme of test runs is scheduled during 2013 which will include efforts to optimise the amplitude, frequency and modulation parameters of the stimulated gas desorption experimental apparatus. It is evident however that a significant number of coal types would need to be investigated to confirm the hypothesis that coal samples from outburst-prone coal seams show a measurable increase in stimulated gas emissions relative to seams from coal basins with no recorded outburst history.

As a further aspect of these studies, an appropriate health and safety assessment was implemented, to quantify the field exposure to the experimenter in the vicinity of the apparatus and determine whether this presents a hazardous field level and what specific control measures are required.

The other research being conducted in this area is to examine the potential use of advanced electromagnetic methods for monitoring and characterisation of overstressed zones and other geological-stress anomalies which lead to gas outburst conditions. This involves:

(i) Investigating the scope to use electromagnetic radiation (EMR) from coal samples subject to uniaxial stress in the laboratory to determine relationships which will point to the outburst propensity of the associated coal seam, and

(i) Investigating the feasibility of employing innovative passive electromagnetic methods to monitor and detect outburst precursor events underground.

A number of approaches were identified to improve the sensitivity and selectivity of the EMR detection process. The EMR studies point to its value as a potentially useful precursor indicator of major strain release events, including coal and gas outburst.

A test arrangement was set up to provide a means for assessing EMR from mine core samples and hence assessing the potential outburst risk presented by local seam conditions. Initial baseline tests used a sandstone core and later tests used UK bituminous coal samples under a uniaxial load. EMR signals were obtained for both; however, there was significant variation in the EMR amplitudes for the coal samples, which is probably a function of the inhomogeneity of the samples.

From the testing, it is clear that a great deal of further work is required to establish whether coal samples tested in this manner can provide useful predictive information on the seam susceptibility to outburst. It is possible that the characterisation of stimulated gas emission under an imposed high electric field, mentioned above may eventually provide more insight here.

The barrier protection part of the research is investigating whether adapted motor vehicle 'airbag' technology can be used to develop a system for protecting face workers from material thrown into the face chock track. The final part of these studies included an extensive analysis of historic outburst events worldwide, including outburst duration of gas emission and material, and tonnages of material ejected, as an indicator of outburst size and violence.

The most violent outburst events have a magnitude and duration (<1s) where it may not be practicable to engineer a protective scheme with a sufficiently short activation time. However the analysis showed that there is a reasonable body of evidence to suggest that a worker protective scheme would usefully address the general body of less extreme outburst events, which constitute a large proportion of all outburst event classes observed to date.

Attempts were also made to assess the likely distribution of gasses and particulate from the outburst release point. This has relevance to deciding the location and number of outburst detection points which would need to be engineered in any practical coalface walkway protection scheme.

Lastly, the range of material options for a protective barrier were investigated, together with an examination of the material test standards which might apply for deployment underground in an ATEX environment.

Low Carbon Mine Site Energy Initiatives [Lowcarb].
Energy storage study and work on compressed air systems and the geotechnical potential of abandoned shafts for compressed air energy storage is being undertaken primarily by the University of Nottingham, with contributions from MRSL and CSM.

Following the work described last year, further numerical models have been developed using FLAC2D to simulate the behaviour of a disused circular mine shaft as a CAES facility.
These models are briefly described as follows:

1) Shaft cap width
The modelling results in the previous models suggest that the shaft cap width has a very limited influence on deformations of shaft liner and shaft caps. Further models with smaller shaft cap width were conducted to double check this conclusion.

2) Shaft cap thickness
The modelling results in the previous models show that the maximum displacement of the shaft cap initially increased and then decreased as the cap thickness increased. This was an questionable result that required investigation. The model was updated to identify the source of the inaccuracy and to correct the results.

3) Weaker ground condition
As this research focuses on the behaviour of the shaft liner and shaft cap under gas pressure, so the surrounding soil and rock field has been simplified to a single type of rock rather than a complex mix of soil and different types of rock strata. In the previous model this rock was siltstone. In later modelling it has been changed to mudstone. As mudstone is weaker, this modelled cases represent weaker ground conditions.

4) Changes to the treatment of the shaft liner
This model is designed to investigate the effect of the liner-rock interface (especially at the position close to the ground surface) on the behaviour of the shaft when there is no grout behind the liner.

5) The effect of a geological fault through the shaft
In an extreme case, this model aims to study the effect of geological faulting on the behaviour of the shaft liner under inner gas pressure.

The project is concluding with an investigation (mentioned in last year's report) into the potential for the structures of existing recently closed, or soon to be closed shafts to be engineered to make them suitable storage vessels for compressed air storage.

MRSL conducted a literature survey into the permeability of concrete to air at high pressure, which revealed that there is a very limited amount of information on this subject that is available in the public domain. Consequently it was decided to address this subject experimentally. A test rig has been designed and is currently being manufactured. This will be used over the next few months to test ordinary concrete linings, concrete with a range of additives aimed at reducing permeability, and also with surface sealants and linings.

In terms of evaluating structural risks for a potential CAES reservoir, the detrimental effects of static build-up were studied. The main risk in this application was considered to be a spark-induced explosion in the event that methane is present in the reservoir. Consideration was given to (a) the possibility of determining the severity of such a risk, (b) preventative measures, and (c) the use of sensors to detect any static build-up.

Risks associated with the migration and stimulated emissions of mine gases into surface buildings were investigated. These could relate to the ingress of mine gases into buildings which may be on the former mining site but, alternatively, could be some distance from the mine due to the possibility that gas could migrate through horizontal fissures as a result of converting the mine into a CAES facility. Consideration was given both to the changes to the drainage of AMM that would result from the conversion of a shaft to a CEAS reservoir and secondly to the possibility of a catastrophic failure to the lining of the shaft comprising the CAES reservoir.

Advanced tools for ventilation and methane emissions control (AVENTO)
Project partners: AITEMIN (Spain), DMT (Germany), EMAG (Poland), GIG (Poland), Hunosa (Spain), ROMANIAN MINE SAFETY EXECUTIVE, KHWSA (Poland), University of Nottingham

The AVENTO project aims to develop advanced tools for the improved control of ventilation networks in underground coal mines for improved safety at working areas through a better control of methane emissions and climatic conditions and through the optimization of the ventilation air flow which will reduce energy and maintenance costs.

Planned work covers all aspects of the problem, including the development of new concepts in monitoring and control systems, advanced methods for the dynamic regulation of air flow as a function of actual needs, modelling activities, hardware and software development; and important experimental work in underground mines and testing facilities.

The University of Nottingham is concerned with developing computational models of the airflows within single entry drivages for when the auxiliary ventilation is either deliberately or accidentally turned off. Under these conditions, the drivage will become gas fast and we are exploring various ventilation strategies to most safely clear the methane from the heading. In addition, we are using 1D network models to trace the methane that has been cleared from the drivage as it moves through the main ventilation network.

Study of stability issues associated with Potash and Polyhalite extraction at Cleveland Potash, Boulby Mine.
As mentioned in last year's report, the University has been asked to develop some numerical models of a variety of mining excavation scenarios for alternative working layouts in the Potash bed. The modelling has been based on dimensional data supplied by the mine and the results of laboratory testing, at the University, of rock samples from the strata column surrounding the mine workings.

The outcome of this work is, in part, a contribution to the mine's decision making process on how such deposits might be mined, but also is being used to develop experience with, and confidence in, numerical modelling as a planning tool in real mine situations. As numerical models inevitably include a degree of simplification of the mine layouts and a variety of assumptions in the input data to allow them to run, the latter will be achieved only from a review of actual closure data from the mine and its comparison with that predicted by the modelling.

[back to top]

Ground control

COmplex Mining EXploitation: optimizing mine design and reducing the impact on the human environment (COMEX)
Project partners: INERIS (France), GAUK, University of Nottingham (UoN), CERTH (Greece), GIG (Poland), GEOCONTROL (Spain), DMT(Germany), UK Coal.

The work of University of Nottingham focuses on modelling of the vulnerability of buildings to mining-induced subsidence. The work will identify a group of specific building types which are typical of buildings found within coal mining areas and which are vulnerable to damage from mining induced ground settlements.

The modelling work involves physical modelling using the Nottingham Centre for Geomechanics 2.0m radius geotechnical centrifuge. Centrifuge modelling allows replication of highly complex and non-linear soil-structure interactions within small-scale and economically feasible experiments. The physical modelling work includes:

- development of methods to model the shape and magnitude of mining induced ground settlements,
- fabrication of small-scale models that realistically replicate full-scale prototype building behaviour,
- evaluation of the magnitude and mechanism of transmission of strains from the ground to the buildings, and
- assessment of the degree of damage to prototype buildings based on the response of the model buildings.

UoN will also be conducting numerical modelling of the subsidence-building interactions using FLAC-3D. The physical model results will aid the validation and calibration of the numerical models. The numerical modelling allows for a more efficient means of testing a wider range of scenarios and material parameters than full-scale or model-scale experiments. For this reason, the numerical models will be used to study the full group of building types identified as well as the sensitivity of results to the variation of key material parameters.

In additions to this, both physical and numerical modelling will be used to evaluate a series of mitigation techniques which can reduce potentially the effect of mining subsidence on buildings.

Golder and UKCoal are collaborating in studying issues concerned with mining in seams which have previously been underworked. This is important for the current Deep Soft longwalls at one colliery and future mining at another (Silkstone above Beeston).

At one mine, the Deep Soft longwall gate roadways are being driven in and around subsidence troughs created by previous undermining by longwalls in the Parkgate seam some 35-40 m below. They are also affected by much earlier overworking in the Top Hard some 120 m above. A combination of experience, the guidelines developed under the previous *PRESIDENCE* project, careful examination of the complex mining history and the results from new and previous numerical modelling have been applied to develop the latest 5 year plan layout and working sequence for this area of the mine.

A numerical modelling exercise using MAP3D, FLAC 2D and FLAC3D and applying the procedures developed under *PRESIDENCE* has been commenced to back analyse the experience of driving one of the gates directly above an underlying pillar/goaf edge. Geotechnical instrumentation, comprising rockbolting telltales, multi height extensometers and rib closure measurements, is being installed, read and recorded in the gate roadways in order to quantify their performance and compare with expectations, with a view to revision, if necessary, of the guidelines previously developed under Presidence.

Geomechanics and Control of Soft Mine Floors and Sides [GEOSOFT]

This Project commenced in July 2010. Golder (GAUK) is the co-ordinator with UKCoal, the University of Nottingham (UoN), three Polish and one Spanish Partner making up the consortium. This Project concentrates on geotechnical problems associated with soft floors and sides. The Polish partners' research is concentrating on powered supports working on soft floors. The Spanish partner is working on in-situ shear testing of rockbolts, application and modelling of shotcrete performance and alternative tunnel profiles. The UK partners' activities are centred around improved control of floor and sides in longwall gateroads.

UKCoal have provided a large quantity of coal and weak floor samples for testing, have commissioned and tested new reinforcement products and strategies in the field and are recording actual strata behaviour for improved understanding, model comparison and validation.

Nottingham University's work over the period has included improved collection, preparation and geomechanical testing of weak rock samples, including pre and post failure triaxial testing and creep; a study of coal measure strata weathering, including temperature and humidity cycling, variation in water acidity, examination by Scanning Electron Microscope and comparative strength tests; and development of a FLAC3D gate roadway model incorporating creep behaviour.

A large database of test results has been developed though the creep and weathering tests continue. Interesting results obtained to date include lower than expected laboratory derived creep properties and no significant effect of particle size in the large triaxial cells tests.

Whilst the laboratory creep test results were awaited, the FLAC3D creep model, developed last year, was enhanced and applied to gates using creep data derived from the literature. This axisymmetric model was unable to represent the differences in support applied to the two rib sides (steel on the solid side and GRP on the face side) and tended to underestimate actual rib deformation for the site. A new model, incorporating the full roadway section, has been developed and will be set up with the laboratory derived strata creep properties. The final stage will be to investigate whether the new creep model will require further enhancement to incorporate weathering effects over time.

The search for improved materials and techniques for rib and floor control continued. Initial development and testing of a cuttable oriented polypropylene rockbolt was curtailed as it was unlikely to produce a practical product with the required properties. LSEP testing was undertaken of further Australian long tendons and those currently

used in the UK (cuttable and non cuttable) using the new split cylinder test with restricted rotation. This test is suited for comparison of axial reinforcement properties of coal mine rib tendons and should be considered for incorporation into a Standard for rib reinforcement consumables. These tests did not identify any products with improved properties over those already established in the UK.

UKCoal undertook successful trials and introduction of a new plastic rib mesh (Mingrid) which is less easily ripped than the product it replaces and a new injection material (Geofoam), a urethane-silicate with improved pumpability and foaming properties. The latter was particularly successful for face consolidation during salvage preparation.

GAUK undertook FLAC3D modelling to investigate the potential of GRP floor bolting at sites which suffered particularly high levels of heave on development. This indicated that a relatively low reinforcement density might make be effective. A trial of floor dowelling did not achieve expectations and consequently it was not trialled further. However, Bevadol/Bevadan PUR floor injection was successful and this was successfully adopted to control the floor during retreat.

Detailed in-situ characterisation of floor and side behaviour was completed at specific study sites at 4 UK collieries achieving improved understanding of the deformation mechanisms at each. Schematics were developed to represent the key driving mechanisms which, combined with the numerical modelling being undertaken, are expected to provide an important tool for development of appropriate support management and risk assessment systems tailored to each site.

Specific FLAC3D modelling exercises undertaken during the year by GAUK under the Project, utilising this understanding, included; consideration of appropriate face handing, and examination of the consequences of retreating one face before another completes retreat.

Also, a general comparison between modelled and measured rib displacement and floor heave was undertaken for the study sites where measurement data was available. This indicated reasonable agreement for roof and ribs on development but larger discrepancies for face retreat and for floor heave in general. The discrepancies for face retreat are likely to be associated with inaccuracies in predicting the associated abutment stresses (using MAP3D) and those for floor heave with the difficulties in modelling large displacements with a Continuum model such as FLAC.

A number of alternative stress analysis packages were considered (LaModel, FLAC 3D, 3DEC and MinSim), further prompted by discrepancies identified with modelling multi-seam interaction stress distributions. It was concluded that none would be suitable for capturing the large scale mining geometries associated with existing and ongoing production panels whilst incorporating stratigraphic layering as would be required. It was concluded that improved floor modelling could be achieved if more interfaces could be incorporated to better capture the layered mode of floor failure observed in the field. To achieve this a mesh/grid pre-processor would be required and this might best be achieved by reverting to using FLAC2D for unbolted floor heave modelling. This has been implemented using the embedded FLAC FISH programming language and initial tests appear promising.

Management of minewater discharges to mitigate mining risks for the post-mining period [Manager]
The project aims to mitigate environmental risk connected with mine water discharge through identifying priority substances of concern in mine water, development of cost-effective and sustainable passive and active treatment technologies, and identification of possibilities for mine water re-use and metals recovery. Pilot schemes in different European countries are expected to be implemented.

[back to top]

Mine operations

Mine Shafts: Improving security and new tools for the evaluation of risks [MISSTER]

The objectives of the UoN contribution to this project includes characterisation of the behaviour of shaft lining elements, an estimation of the effect of time and an aggressive mine water environment on these elements, and the use numerical and physical modelling to analyse shafts (stability, failure mechanisms.

UoN is focussing its work on evaluating the degradation of brick, mortar, concrete, and brickwork panels with time in mine water to study the effect of an aggressive environment on the lining and shaft materials.

Many old shafts are lined by multiple rings of brick in the UK. To analyse the stability of these shafts, it is important to simulate realistically the behaviour of the brickwork lining. However, due to lack of literature, the behaviour of brickwork lining is relatively poorly understood. Two issues, time and water effects on the brickwork, are particularly important in this context since the strength of the brickwork could be considerably degraded with time and chemical attack. In order to have a better understanding of the time and water effects and collect realistic parameters of brickwork, weathering tests have been conducted. The weathering tests involve two sets of experiments:

- Immersion tests: to replicate degradation of shaft/fill/capping materials.
- Laboratory tests: to evaluate weathering effect on structural parameters of the test materials.

Test samples include: cylindrical samples of brick, mortar, and concrete; and brickwork beams designed for testing according to BS EN 1052-2. The samples are placed into four different solutions to perform the immersion tests. At different times, the samples are collected from the solutions and a variety of laboratory tests (Uni-axial compressive strength test (UCS), Tri-axial compressive strength test, Scanning electron microscopy (SEM), Four point bending tests (FPB)) are conducted.

Physical modelling in the University of Nottingham geotechnical centrifuge allows for the study of failure mechanisms of shaft linings near the ground surface. The purpose of this task is to study the behaviour of superficial soils and shaft linings post-failure and to determine the effect of discrete weakened zones within the shaft lining on the resulting subsidence. This will ultimately provide valuable data which may give insight into the location of shaft rupture based on post-failure ground surface profiles.

Numerical modelling is used to evaluate the effect of the deterioration of shaft elements on overall stability of the lining. To obtain input properties for numerical models for shaft lining, in this stage, two scales of numerical models have been set up:

1) Small scale models – four-point bending test according to BS EN 1052-2

The laboratory four-point bending tests of brickwork beams determine the flexural strength for a plane of failure perpendicular to the bed joints. This test is used to validate the small scale FLAC3D model, to obtain the equivalent material properties for the brickwork (i.e. a composite material is treated as a uniform material). The obtained equivalent properties will then be used in the modelling of the brick-lined

shaft stability analysis. This stage is necessary since numerical models which replicate individual brick and mortar elements are very computationally expensive and would not be feasible for this analysis.

For the beam models, a significant effort is made to numerically simulate the behaviour of the brickwork as close to the real situation as possible. This is done by introducing interface elements into the model to represent the bond interface between the brick and the mortar in brickwork.

The effect of the number of the interfaces is studied as an attempt to determine the minimum critical number of interfaces to obtain accurate results. This is expected to help simplify the large scale model for stability analysis of shaft lining, with interfaces representing the bond between brick and mortar. The scale effect of the models for obtaining the interface properties is also investigated. In addition, discrete element method (DEM) is utilized to study the behaviour of the brickwork. A preliminary model is set up via UDEC code and the results are compared with those from the same model in FLAC3D code.

2) Large scale models – study on factors of stability of shaft lining

In large scale models, the brickwork lining is treated as a uniform material and the equivalent properties obtained in small scale models are being adopted. The effects of shaft treatments and possible point loading on shaft lining on stability of the shaft lining are being studied.

Most of MRSL's research into geophysical imaging techniques to locate old mine shafts was completed and reported in previous years. Recent work centred upon a "plug and play" system for connecting electrode switches together in the field using less expensive patch cables. A novel "plug and play" architecture for smart electrodes, offering major cost, productivity and ease-of-use benefits, was devised. A top-level electronic design capable of achieving this was produced The key to the "plug and play" architecture is the automatic allocation of sequential addresses and a simulator of the electrodes switches was developed, as a means of developing sample software to permit the demonstration of an algorithm for executing this automatic allocation.

In parallel, research was carried out into the software technique of inversion that is required to interpret the results of an earth resistivity exercise, and approaches for optimising it for the detection of mine shafts were developed. Once a commercial opportunity has been identified, an engineering team would be capable of translating the output of this task into a component-level design and production software as a product development exercise.

Studies undertaken relating to analysis of the critical constitutive elements of shafts, which influence the risks of failure over time has been on-going. Testing has been undertaken for almost two years into the durability and compressive strength of fibre reinforced concrete and 'established' steel reinforced concrete, when subjected to acid or potable water environments. Test cubes showed very little change in weight over the period, but deterioration of the surface of some cubes was noticeable. However, the compressive strength was some 12% - 15% less than samples left in a normal 'air' environment. Overall, the use of fibres in concrete showed less of a reduction in compressive strength in potable water, but a similar performance to conventional steel reinforcement in acid water.

RFCS Project INREQ RFCR-CT-2012-00002: Enhance Effectiveness and Safety of Rescuers Involved in High Risk Activities by Designing Innovative Rescue Equipment Systems.

This Project commenced in July 2012 and is co-ordinated by KOMAG of Poland. There are 7 partners, Golder being the sole UK partner. Golder's part is to develop the m-Comm system, which is currently designed for mines rescue voice communication, to include the capability to transfer biometric and environmental monitoring data from the forward rescue team to the fresh air base. Work over the first six months has concentrated on basic specification of the system architecture and identifying the appropriate protocols and interfaces both for data input at the rescue team and data export at the fresh air base.

An essential aspect is the avoidance of collisions between monitoring data and voice comms data. The embedded software for the inbye "hub" units to achieve this is currently being designed. The base unit requires a separate and purpose designed module to extract and decode the data transmission and an output interface. It is envisaged that this output interface will take the form of a WLAN wireless link as well as an ATEX approved USB connection. The design of the m-Comm uplink will be undertaken as a complete sub- system which will include the extra data-out module in the base unit.

Discussions with project partners, CSRG and DMT, resolved many open questions regarding sensor selection and interface specification. It was agreed that the proposed data rate of 1200 baud in 300 millisecond bursts was acceptable to all.

Assuming that the system will be able to transmit between 0 and 100 data bursts per minute without interference with voice communications, an update rate of once every 20 seconds should be achievable at the base station. The discussions also explored the options and limitations of biometric sensors, calculation method of maximum operational work time/period, and environment monitoring (mainly gasses).

Currently the most likely candidate for biometric monitoring is a chest monitor manufactured by SEM. This measures heart rate, skin temperature and skin galvanic parameters. Detailed analyses of possible multi gas sensor portable units are also underway. Link Instruments produces a typical example of such a portable gas detector meter with a serial interface for extracting data.

As a result of the investigations and discussions with partners, GAUK is basing its data inputs on a mix of analogue and digital options. Test data transmissions will initially be conducted with simple but accurate temperature and humidity sensors.

[back to top]

Appendix 1 – Members of SHMRAB 2012

Mr J R Leeming, HM Inspector of Mines, (Chairman)
Mr T Spurry, Group Safety Engineer, UK Coal Mining Ltd;
Dr A Curran Chief Executive, Health and Safety Laboratory;
Dr R Stace, School of Civil Engineering, University of Nottingham;
Mr P Carragher, General Secretary, British Association of Colliery Management;
Dr R Quinlan, Medical Director, RPS Business Healthcare Ltd;
Mr J Wood, President, the Union of Democratic Mineworkers;
Mr R Soar, National Association of Colliery Overmen, Deputies and Shotfirers;
Dr P Holmes, British Gypsum Ltd and the Mining Association of the UK;
Mr R A Fenton, Secretary Mining Association of the UK (MAUK)
Mr S Hunter, Cleveland Potash Ltd.
Mr M Padley, Health & Safety Manager, Hatfield Mine, Powerfuel;
Mr M Lawton, Policy Group HSE
Mr R G Siddall, Past President of the Institution of Mining Engineers;
Dr B Jones, Chief Executive, Mines Rescue Services Ltd;
Mr P Shorthouse, SES Contracting Ltd;
Mr C Kitchen, National Union of Mineworkers

Others who contributed to SHMRAB meetings during 2012
Dr P Foster, Camborne School of Mines, University of Exeter;
Mr D Bigby, Golder Associates (UK) Ltd:
Mr S C Bennett, Mines Rescue Service Ltd;
Mr N Hill, HSE, Secretary to SHMRAB;

SHMRAB Secretariat
HM Inspectorate of Mines
Foundry House
3 Millsands
Riverside Exchange
Sheffield S3 8NH
UK

[back to top]

Appendix 2 - Contact details for researchers mentioned in this review

- **The Health and Safety Laboratory**
  http://www.hsl.gov.uk[10]
  hslinfo@hsl.gov.uk
- **Golder Associates (UK) Ltd**
  http://www.rmtltd.com[11]
  rmt@rmtltd.com
- **Mines Rescue Service Ltd**
  http://www.mrsl-research.com[12]
  d.gibson@mrsl-research.com
- **University of Nottingham**
  http://www.nottingham.ac.uk/ncg[13]
  geomechanics@nottingham.ac.uk
- **UK Coal Mining Ltd**
  http://www.ukcoal.com[14]
  enquire@ukcoal.co

[back to top]