



Improving the safety performance of the UK quarrying industry through a behavioural based safety intervention

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Synopsis

This paper summarizes a behavioural safety project undertaken in seven quarries in the UK in order to investigate its applicability as a means of raising the standards of health and safety in the UK quarrying industry. A behavioural safety methodology was developed and trialed at two quarry sites in the UK. During the study the number of unsafe acts and minor accidents had decreased and at one of the quarries there was a 95% reduction in the number of working days lost. It was then introduced at a further five sites of varying sizes and within this focused specifically on lone workers as well as behaviours that affected quality and environmental issues. Positive improvements were noted in most of these operations. The project also looked at the effectiveness of health and safety performance indicators. Here, the common lead and trailing indicators for both safety and health that are commonly used by industry were identified. In consultation with the UK quarrying industry these were then used to identify specific performance measurement criteria that can be used by the quarrying sector to measure performance. Following on from this, a quarry specific health and safety management system specification was developed for large and small quarries.

Introduction

Quarry safety in the UK

Quarrying in the UK is still a significant industry. There are approximately 3 000 quarries in the United Kingdom employing some 35 000 people. The industry produces an estimated 290 million tonnes a year, and mineral extraction and processing contribute approximately 8% of UK gross domestic produce (Foster and Pearce, 2003).

An analysis of accident statistics shows that quarrying in the UK is a dangerous industry with a poor safety record. It has injury rates that are far greater than those in the UK construction industry, which is considered as the dangerous industry in the UK. In a comparison of the accident rate of the UK quarrying industry with that of some major international mining companies, it was noted that UK had by far the highest rate (three times the average of these companies), and over the years there has been little discernible improvement in this.

Following the introduction of the 'Revitalising Health & Safety' initiative by the UK Government in 1999, the Health & Safety Executive's Quarry National Joint Advisory Committee (QNJAC) introduced the 'Hard Target' campaign with the objective to halve the number of reported accidents in quarries over a five-year period. All the major companies and associations in the quarrying sector signed up to this. In 2005, at the end of the initiative, a reduction of 52% was noticed. Following this success a second target based initiative (2005–2010) was announced with the aim to achieve a further 50% reduction in injuries by 2010 with the ultimate aim of zero incidents by 2015. This is known as 'Target Zero: A World Class Industry'.

Achieving 'Target Zero' by or in 2015 will be possible but it is important to keep up the momentum built up in the 'Hard Target' and continue to reduce accidents in future years. The question is how do we continue this momentum in the short term and what can we do in the longer term? In order to achieve this, a number of specific areas were identified for study. These are competence, behavioural safety and performance indicators.

The research project

In 2004, the authors embarked on a three-year research project funded through the UK Aggregates Levy to investigate means of raising the standards of health and safety in the quarry sector. In particular it focused on two of the areas identified above, namely behavioural safety and performance indicators (Foster *et al.*, 2007). Here the focus was on two particular quarries for the behavioural

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© The Southern African Institute of Mining and Metallurgy, 2008. SA ISSN 0038-223X/3.00 + 0.00. This paper was first published at the SAIMM Conference, Surface Mining, 11-14 August 2008.

Improving the safety performance of the UK quarrying industry

safety component. Two further grants were awarded allowing the behavioural safety initiative to be spun out to five more quarries (Parand and Foster, 2008)

Behavioural safety

The role of human error and unsafe behaviour in accident causation has long been recognized. Over the years the quarrying industry has used engineering solutions to solve many of its safety problems. For the industry to improve continually on its accident record, some effort must be applied to looking at the human element and in particular in influencing behaviour.

As part of this project a behavioural safety process was developed and implemented in a total of seven quarries. This is summarized further in this paper.

Health and safety performance indicators

Traditionally safety has been measured using trailing indicators such as the number of accidents. In order to be able proactively to measure safety there is a need to identify what the key leading indicators are in the quarrying industry so some benchmark can be found. These lead indicators are much more likely to influence (or predispose) trailing indicators (and hence, the number of accidents) and should therefore be linked to control measures or the effectiveness of any safety management system. The advantages of measuring performance this way is that many different aspects can be measured concurrently, indicators can be tailored to suit local needs, and it is easy to link them to internal safety campaigns or initiatives.

During this project the common lead and trailing indicators for both safety and health that are used (both nationally and internationally) by all industries were identified. In consultation with the UK quarrying industry these were then used to identify specific performance measurement criteria that can be used by the quarrying sector to measure performance. Following on from this, a quarry specific health and safety management system specification was developed for large and small quarries. This is summarized in further in this paper.

Behavioural based safety (BBS)

Introduction

BBS is the application of psychological research on behaviour applied to safety in order to reduce accident and injury in the workplace. BBS has derived from behavioural learning principles conceived by behaviourists during the late 19th century and developed into an approach through integrating organizational development with quality and safety management (Parand and Foster, 2006).

There is a vast amount of research and academic literature pointing towards the benefits of behavioural change programmes enhancing safety within the workplace. These programmes are known by many as behavioural safety or behavioural based safety (BBS) initiatives that work by applying principles governed by theories on behaviour and through use of objective measures on behaviour, results-based changes, and feedback. The end objective is to improve

safety performance and decrease the number of work-related incidents (injuries and fatalities) through reducing at-risk acts and promoting their converse safe actions.

Empirical studies have shown past successes in application of behavioural safety applications involving techniques such as safety goal-setting, safety feedback, monitoring safety behaviours, reinforcement of safety behaviours, etc. (McAfee and Winn, 1989; Krause *et al.*, 1997). Outcomes from behavioural safety application have been fruitful industrywide, such as, manufacturing plants (Reber *et al.*, 1984); food factories (Komaki *et al.*, 1978); and nuclear plants (Cox *et al.*, 2004).

The evidence implies that BBS is an approach that can be tailored to diverse work settings, with field experts supporting this evidence (Guastello, 1993). However, there have been a limited number of studies that have examined BBS in a minerals (quarrying and mining) environment. To the authors' knowledge, to date, there have only been three academic applications of BBS techniques within a minerals environment in the UK: Fox *et al.*, (1987); Rhoton (1980) and Foster *et al.*, (2007), whilst a greater number of studies have taken place in the international mining industry (e.g. Talbot *et al.*, 1996; Geller *et al.*, 2001; Hickman and Geller, 2003).

An important characteristic of the quarry and mining setting is the small workforce, many of whom work alone. Unfortunately, as well as a lack of evaluative research of BBS with lone workers (Olson and Austin, 2001), there are misleading reports on a fundamental component of BBS. Specifically, due to the majority of previous BBS research concentrating on work environments that are conducive to work colleagues systematically monitoring one another's safety-related actions (Hickman and Geller, 2003), often reports describe this use of peer-reporting as vital to the BBS system (Krause, 2002). Yet, as well as being incompatible with the physical layout of a quarry, the culture of the close-knit quarry is one where operatives are suspicious of providing information on their fellow workers' bad habits, perceiving it as 'snitching' on their colleagues. The developed process had to take this into account with part of the focus on lone workers.

The BBS research study

Overall the BBS methodology was introduced at seven sites across the country of which one was classed as large in size (over 100 employees), three as medium (51–100 employees) and three as small (fewer than 100 employees). At each site, a project steering team led the BBS process helped by a facilitator who was one of the researchers. The teams are made up of front-line employees (operatives) and supervisors from both quarrying and processing operations.

The BBS process was initially introduced and trialed in two of the quarries before being spun out to the remaining five having proved successful (see Foster *et al.*, 2007). In the second phase the approach was to adapt the process to focus on self-auditing and lone workers (as these smaller quarries had a majority workforce of lone workers), as well as to adapt the process to focus on additional non-safety aspects in the quarry, i.e. environmental and quality (see Parand and Foster, 2008).

Improving the safety performance of the UK quarrying industry

At each quarry, the steering team directed the operatives through the six phases of the developed programme, which involve self- and peer observations as the behavioural measure, and feedback, goal-setting and rewards as the instigators for behaviour change.

Phase 1: Introduction of the programme and data collection

Phase 2: Identification of key safety behaviours (KSB)

Phase 3: Behavioural observations (self and peer observation checklists) and training

Phase 4: Analysis of root causes

Phase 5: Making changes, reinforcement schemes, feedback and goal setting

Phase 6: Evaluation of programme effectiveness and plan for continual development

Phase 1: Introduction of the programme and data collection

Initial data was collected through the use of focus groups, questionnaires and interviews to obtain information on the current safety culture, systems and controls and to find out whether the company and the sites in question were ready for such an initiative. Injury and near miss records were also analysed in detail. Management, supervisors, operatives and contractors participated in three separate workshops detailing the underlying principles behind BBS and an outline of the process.

Phase 2: Identification of key safety behaviours (KSB)

A steering team was formed at each site. Their role was to shape and guide the process include the following primary duties: participating in safety steering team meetings on a weekly basis; promoting workforce ownership of the process, identifying and defining key safety behaviours; developing behavioural observation checklists; planning the observation strategy, conducting and assisting with observations; retrieving observation data and storing them in a safe place; providing feedback on progress and safety results; facilitating safety goal-setting; and proposing action plans based on the root cause of unsafe behaviours.

The team carried out individual interviews with workers on what they believed to be the most important and prevalent unsafe actions onsite. One hundred and twenty-seven operators gave their views and ratings on what they perceived as either insignificant or central to site safety based on a list compiled from initial data collection (injury, near miss records and interviews) and steering team meeting discussions. This information was collated and the top 20 key safety behaviours (KSB) finalized.

This involvement from the workforce served to facilitate operative ownership of the programme and increase cooperation and acceptance of checklists incorporating the 20 KSB selected.

Pareto's law dictates that 80% of the consequences stem from 20% of the causes. Applied to accidents, this principle prescribes that, at any given time, 20% of behaviours are

responsible for 80% of accidents. Therefore, logic dictates it is more productive to focus on a restricted number of critical and current behaviours rather than overload the workforce with all safety acts performed on site. The present process involved a parameter of 20 behaviours. Working on the assumption that these 20 behaviours are the current 20 out of 100 behaviours (20%) that are actually responsible for 80% of the accidents, this figure was determined on the premise that this will limit dilution of focus and still be an adequate number of acts to focus on to achieve the desired results.

The KSB themselves had parameters attached to them: they had to be observable, specific and perceived as a major safety issue at the site and/or liable to cause an accident. The selected KSBs were defined precisely to reduce ambiguity of the safety act and increase the reliability of their measurement.

At two quarries, some of these KSBs were replaced with behaviours that could affect the environmental and quality aspects of their operations.

Phase 3: Behavioural observations (self- and peer observation checklists) and training

The purpose of this phase was to obtain a current baseline measurement of the KSB and simultaneously gauge the operatives' preference for self- or peer observations on these 20, as well as assessing the observational measures themselves through comparison of the safety results from these two different methods of assessment. The one-tailed hypothesis was that the majority of the workforce would favour the method of self-reporting. This was based on consideration of the nature of quarries as having a physical layout unsupportive of peer monitoring and on operatives' loyalty to co-workers influencing them to prefer reporting their own prohibited actions rather than informing on the prohibited actions of others. Training was provided to all operatives and a 'no blame' policy put in place guaranteeing that no one would be disciplined for anything written on the checklists.

All operatives, including hauliers and other contractors, were offered the choice to complete either a 'self-report' checklist or a 'peer-observation' checklist. These checklists cover the same 20 key safety items with different phrasing. The self-report sheet allows operatives to record and comment on their own safety actions, while the peer-observation sheet enables logging and comments on the safety actions of others onsite. At the end of the quarry workers' shifts, steering team members collected completed checklists. These checklists were either placed into election type boxes scattered around the site, or handed back directly to the members, often via work group team leaders.

In order to capture the baseline measure of KSB, operatives were instructed to conduct observations on a daily basis for one month. To obtain a concise measure of the KSB from the checklist responses, the Behavioural Safety Index formula (Komaki *et al.*, 1978) was used. This divides the number of safe observations by the total number of safe and at-risk observations, multiplied by 100.

Improving the safety performance of the UK quarrying industry

In addition to the operatives' baseline measurement, the steering team carried out their own month of peer observations. This acted as a cross-check on the operatives' checklist safety scores and was designed to enable future safety targets to be based on this objective base measure. Further accuracy checks on the reliability of the steering team's observations were carried out by dividing the number of times observers agreed by the total number of times observers agreed and disagreed, multiplied by 100. The steering team's IOR was at 100%.

Phase 4: Analysis of root causes

Analyses of the key safety behaviours were used to arrive at the underlying reason for the at-risk behaviours.

As part of 'functional analysis', the A-B-C technique was used on the comments from the back of the checklists and from the information gathered in Phase 1. The A-B-C approach involves drawing out the antecedents (or cues) of the behaviour and its consequences.

Figure 1 shows a study example of ABC analysis on the KSB of 'use of incorrect traffic routes'.

Operatives were also involved in the identification of the root causes, via each steering team member asking people why they carry out at-risk KSB.

Phase 5: Making changes, reinforcement schemes, feedback and goal setting

Based on the core root causes exposed, strategic plans were drawn up to act on the instigators of poor safety performance. Proposed strategies were assessed in terms of estimated impact on safety and on expenditure. The action plans were submitted to management via an operations meeting, along with evidence in the form of summarized operative responses.

The interventions and proposed changes comprised adjustments on safety controls (e.g. training), amendments to certain antecedents (e.g. signs, safety targets, relocation of safety equipment), redesign (e.g. seat belts) and consequences (e.g. rewards for safety).

Phase 6: Evaluation of programme effectiveness and plan for continual development

Towards the end of the BSQ initiative, the final phase was to evaluate the programme effectiveness of safety performance and in terms of applicability of measures. The difference between baseline and intervention will be analysed. This includes a comparison of the accident rates, safety attitudes

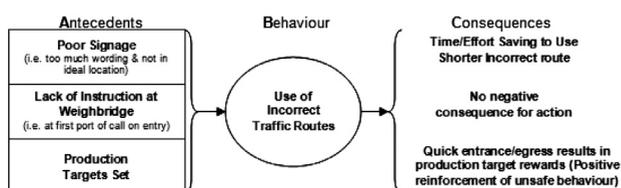


Figure 1—Example of ABC analysis

from the questionnaires, and a comparison of the safety percentage levels on a second behavioural measure that will be taken over one month to determine the progress on the KSB.

Results and discussion

Change in behavioural safety index

The line graph in Figure 2 shows the progression of the behavioural safety index (BSI) percentage from the baseline study at the beginning of the study (two quarries) to that measured after the study and intervention. The measures of 20 KSB reveal a noticeable positive increase in the safety level at both sites.

This increase in BSI percentage appears to be a positive indication that the process has increased safety behaviours at both sites. However, the fact that the BSI started to increase from the beginning of the baseline may suggest that there was something else, other than the BBS programme, contributing/causing this rise. One explanation for this increase is the phenomenon of the 'Hawthorne Effect'. This refers to the effect of the sheer presence of behavioural monitoring alone inducing the desirable behaviour being measured.

Moreover, while the measure was intended as a baseline period, certain behavioural techniques were involved: weekly feedback, visual and verbal, were used to achieve buy-in of the programme. Benefits of the behavioural practices may further explain the improvement in performance. For example, the operatives heighten their awareness to what they have agreed on as the most common unsafe acts on site, and by approaching others to ask for their reasons for acting unsafely communication on safety is increased and instigates displays of 'propensity to actively care' (i.e. the pro-social tendency to help towards a safer workplace).

For sites 3-7 more detailed analysis was undertaken of the BSI against the ratings given in both peer reports and self-reports, and between ratings given by the steering teams and by the operatives in general. This is because more emphasis was put on lone workers and self-reporting in these quarries.

In each case there was similarity between these different measures, but it was observed that the steering team ratings (peer reporting) were slightly higher on the KSBs than the operatives (self-reporting). This may be taken to suggest that

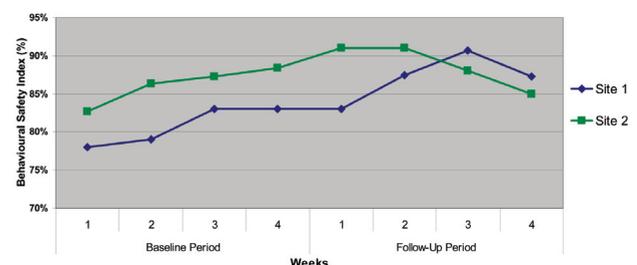


Figure 2—BSI percentage at site 1 and 2 during baseline and follow-up observation periods by operatives

Improving the safety performance of the UK quarrying industry

the presence of peer reporting on site may cause this increase in desirable behaviour, indicating that peer reports on site may be better than having self-reports alone. Yet, to a lesser extent, it has also been found that self-monitoring can improve the monitor's safety performance.

Accident (LTA) data

To judge other tangible performance indicators for the behavioural safety process, accident records were examined. For the first two sites the number of accidents were compared during the baseline period and during the intervention period. The intervention phase (the period where changes are made based on analysis and observations on the 20 KSB) These were both measured over a seven-month period.

Figure 3 depicts insignificant decreases in both lost time accidents (LTA) and minor accidents. LTAs have slightly decreased at site 1 and slightly increased at site 2. Minor accidents have decreased at both sites.

Figure 4 shows that the number of days lost due to injury at site 1 has been reduced by 95% in the intervention period, while at site 2 no change was noted.

In the remaining five sites, with the exception of one increase in accidents at a small quarry and two consistent accident scores, all of the days lost, LTA, and minor accidents showed a positive decrease.

These results provide some support that the general BSQ process has had a positive effect on reducing accidents at both medium and smaller quarry sites. Yet, even when comparing the smaller quarries with the medium quarries, the raw accident data present similarity, despite the logical expectation that quarries with more people would have more accidents. Therefore, it is more complicated to examine differences between how BSQ has affected the accidents between different size sites.

As is always the case with monthly accident figures, the changes are slight, so no significant conclusions can be directly drawn from these figures alone and it may hide patterns that would possibly emerge with larger numbers of sites.

Lastly, a final telling outcome from the project was that many of the KSB at each site were common. These were: use of three-point rule, speed, use of traffic routes, driving with vehicle butt raised, cleaning spillages, priority to loaded/larger vehicles, seat belt use, removal of trip hazards,

PPE use, near miss reporting, running/rushing, load carried over distance, use of tools, and use of safety harness.

SHEQ integration

Two sites undertook the integration of SHEQ related behaviours into their KSB. Here, fewer quality and environmental behaviours in comparison with the number of safety related behaviours were identified and included at both sites. This was justified on the basis that there simply were fewer environmental and quality issues onsite. Fewer health behaviours were also put forward compared with safety behaviours. In support of hypothesis from the initial literature review, discussions by the steering team justified this exclusion of certain important health issues on site by describing the inherent nature of health-related behaviours as difficult to observe and thus difficult to include in an observational-based process.

The following environmental and quality behaviours were identified as primary behaviours to tackle at these two sites:

- Disposal of waste (general)
- Disposal of waste in correct bins
- Water testing
- Informed of shift product
- Damping dust
- Labelling (containers/bags)
- Loading close to concrete supporting stockpiles.

While this environmental and quality list was generated with the same BSQ procedure applied to safety behaviours, more relevant sources of data were considered. Information was sourced from external quality complaints, external environmental complaints and environmental guidelines

From examination of the SHEQ results that have been achieved to date, there has been an improvement in three out of four of the environmental and quality behaviours in the months that the BSQ process was in place at the sites.

Barriers and enablers for success

While comparing the implementation of the process at smaller quarries with larger quarries, it was found that smaller quarries hold some of the following key enablers and barriers that may influence a BBS initiative:

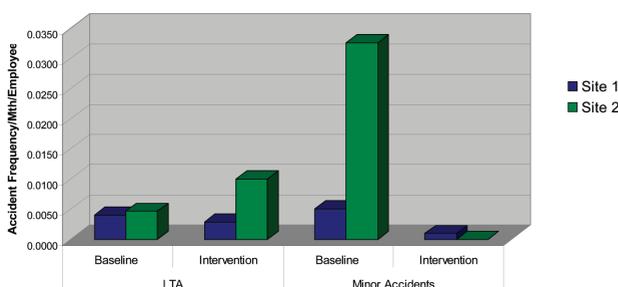


Figure 3—Lost time accident (LTA) and minor accidents at baseline and intervention periods

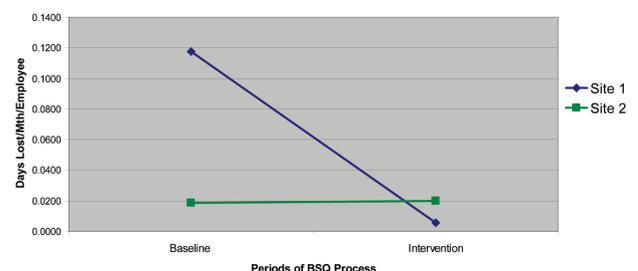


Figure 4—Days lost from absence of an employee due to an accident during baseline and intervention periods

Improving the safety performance of the UK quarrying industry

Barriers

- Inadequate historical records and information
- Lack of certain information or systems to hold information
- Reporting cannot be divided by work area, resulting in less specific reporting information
- Increased difficulty in convincing employees of anonymity pertaining to project
- Fewer human resources available to guide the process.

Lone workers on site present the additional barriers to a BBS initiative:

- Increased difficulty in formation of strategies to introduce consequences, etc. for all those on site
- Increased difficulty in communication to lone workers.

Enablers

- Quicker communication of crucial BBS practices, such as feedback
- Potential for quicker buy-in of workforce
- Less time needed for almost all phases.

Leading indicators research

Introduction

The research started by reviewing a wide range of sources from management models and consultancy approaches to academic papers in order to identify potential OHS leading indicator areas and to rationalize these to create a practical template for research. Very little was identified that had proved a direct relationship between such indicators and later OHS performance in terms of numbers of injuries or diagnosed industrial diseases, but by taking as wide a range of proposed areas as possible, it was postulated that a comprehensive model for prediction would be viable.

The following work was of particular interest to the review:

Gallagher (1997) investigated the characteristics of twenty companies from different sectors, rating them against audit criteria to define the companies into four general 'types':

- Traditional management (OH&S lies with local supervisor and OH&S professionals, low employee involvement)
- Innovative management (management has key OH&S role, high employee involvement, integration of OH&S into broader management systems)
- Safe place control strategy (control hazards systematically with design)
- Safe person control strategy (control employee behaviour).

These characteristics were then cross-typed and taken against actual OH&S outcomes (accidents, etc.). In general, companies that displayed 'innovative management' with 'safe place' strategies were found to be the better performers.

Iyer *et al.* (2004), working with a forestry services group, used a statistical model to examine the relationship between

incidents and programme interventions such as inspections, training, incentives and safety meetings designed to prevent them. They stated that a point was reached whereby determination of how, when and where to adjust specific interventions was possible. An exponentially decreasing incident rate was related significantly to the level of effort applied. However, the carry-over effect was put only at six weeks.

Van Der Bergh (2003) grouped a number of safety leading indicators under the following categories:

- Leadership (including field visits and communications conducted)
- Safe working (including observations of behaviours, protective equipment compliance)
- Safe place of work (including risk assessments and inspections conducted)
- Competence (including percentage training completed, e.g. in hazard identification)
- Implementing lessons (including percentage incidents investigated, corrective actions).

In all 43 indicator areas were identified. These were shown by Bennett and Foster (2005), together with a system-based linkage to demonstrate how the organizational characteristics that underlie the indicators might interact with each other, all flowing ultimately from senior management concepts, systems and attitudes.

Proponents of behavioural safety support the view that the effectiveness of BBS programmes requires a strong existing culture of safety management to be in place prior to implementation. For example, McClure (2000) described this need as management commitment to safety improvement, effective safety and training policies, hazard risk control, good communication and good fundamental procedure such as for locking-off and confined spaces, thus providing a firm rationale for the relationship between the components of this project.

Field investigations

In order to investigate the effectiveness of these indicator areas in practice, a number of field investigations were conducted with a partner quarrying company. This company had 16 industrial sites spread across the UK, three of which were small (between two and ten employees) and the rest much larger (typically around 60 employees working on various processes and shifts). Visits took place to the head office and to 11 of the 16 sites over a period of five months, including the three largest and the three smallest industrial sites and with a mix across the four management regions.

The approach included observation of practices, site conditions, paper and computer-based systems and emphasized interviews with employees at all levels.

Ultimately, all the data were drawn together under the 43 indicator areas and ratings given on a scale of 1–10 (ten is good) against each in a report that was given to senior managers, following a live presentation of some key parts to explain the approach and general impressions. This was carried forward into improvement actions and notably highlighted potential for increasing workforce involvement in

Improving the safety performance of the UK quarrying industry

safety activity, this being taken by the management as further justification for rolling out the BBS programme, refined from the initial research, across other sites.

Recommendations on leading indicators to the quarrying industry

It was decided to group a number of leading indicators under six 'key leading indicators' (KLI) that would provide an overarching and comprehensive structure. The six KLIs were as follows:

- ▶ Senior management commitment
- ▶ Employee involvement
- ▶ Communication
- ▶ Competence of employees and management
- ▶ Continuous improvement processes
- ▶ Occupational health management.

Table I shows the initial recommendations made to the industry through the Health & Safety Executives Quarry Advisory Committee (QNJAC) this being a shorter, less

qualitative adaptation of the template used in the research in order to be more suitable for wider consideration, although inevitably with some loss in value. The detail of 'contributory indicators' and 'proposed targets' was intended to provoke discussion, while the 'umbrella' of the six KLIs would widen any discussion, provide a test against which initiatives could be considered and could be included in publicity if required.

These recommendations received a good initial response. As the discussion progressed and the implication emerged that, to make this really useful as a set of indicators, companies might be asked to report on their achievement, some caution was encountered from H&S managers. However, the debate about Target Zero has developed over meetings and the six key indicator areas have been accepted as desirable, being subsumed into the work of a number of sub-committees, with 'workforce involvement', 'occupational health' and 'competence' as working topics alongside specifics such as vehicle safety and 'leadership' and 'communication' forming part of the terms of reference for all these groups.

This work on indicators has also, together with best

Table I

Proposed leading indicators of OH&S for the UK industry

Key leading indicator	Contributory indicators	Proposed target
Senior management commitment	MD or similar accepts OH&S champion role	Yes
	MD or similar gives company-wide messages of support for OH&S (written / road-shows / video)	3 per year
	Senior managers appear supporting OH&S activity (presentation photos / visits / handshakes)	6 per year
	High level OH&S objective(s) alongside other board-level objectives. Health as well as safety.	At least one
	All management team meeting agendas mandated to include OH&S	Yes
Continuous improvement	OH&S improvement objectives for all managers fully integrated into operational management objective-setting and review process	Yes
	Competent OH&S audit function in place	Yes
	Comprehensive audit programme (all places and processes covered at least every two years)	At least every 2 years
	Low non-conformity counts (scope-dependent)	Close to zero
	Non-conformities and observations dealt with within four weeks	90%
	OH&S manager regularly involved in operational management team meetings	Yes
	Significant incident root causes investigated (incidents analysed and grouped to show types and trends / procedure for preventive action)	100%
	Risk assessments (RA) and systems of work reviewed for all tasks	At least every 3 years or when changes occur
Communication	Each employee receives toolbox talks or similar interactive discussions on OH&S topics	At least 4 per year
	Each employee receives company-wide messages supportive of OH&S (MD messages/poster campaigns)	At least 4 per year
	Every person present on site has received site OH&S induction (if not accompanied at all times) and has confirmed qualifications for work undertaken	100%
	Publicized recognition of good OH&S practice	At least 1 per year
Competence	Jobs analysed for competence requirements (against national occupational standards) —experience, on-job guidance, skills training, OH&S understanding	100%
	Employees developed to competence within appropriate, defined time scale for the work	100%
	Managers and supervisors receive regular competence review and continuing professional development.	100% At least annual review
Employee involvement in OH&S	Each employee takes part in OH&S involving activity (review of RAs, systems of work/ root cause investigation / site walkabout in small group)	At least one per year
OH management	Risk-based health hazard monitoring and control in place to current nationally quantified standards. Risk-based health surveillance carried out. Rehabilitation procedure in place. (see QNJAC OH guidance)	Zero unprotected exposure to risk outside limits. 100% adherence to guidance.

Improving the safety performance of the UK quarrying industry

practice and legal requirements, fed into another substantial output from this project in the form of a Quarry Health and Safety Management System (QHSMS) for the industry that is described in greater detail by Bennett and Foster (2007). The research that fed into the development of this system led to the conclusion that the OHSAS 18001 specification was a useful and widely accepted model summary of the 'harder' elements of a safety system such as objective-setting and audit and hence the QHSMS was developed so that accreditation to this standard would be an option, while the 'softer' or more cultural requirements such as leadership and employee involvement were built into the strategy and the process control components in a more overt manner than exist in the generic specification. Extensive guidance and model procedures add greatly to the minerals-specific nature of this work, which would be largely applicable to any open pit operation.

Acknowledgments

The research described in this paper was funded by the UK Aggregates Levy through the Minerals Industry Research Organisation MIST scheme (MA4-4-06 and MA6-2-02) and the European Social Fund (ESF). The views expressed in this paper are those of the authors.

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