METHODOLOGY TO DEVELOP AN EFFECTIVE SAFETY PERFORMANCE MEASUREMENT TECHNIQUE (SPMT)

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The construction industry is recognised as one of the more hazardous industries. The major causes of accidents are related to the unique nature of the industry, human behaviour, poor safety management, equipment, difficult site conditions and procedures. Over the years many changes have evolved regarding safety. With the enforcement of the legislation such as the Construction Design and Management 1994 Regulations (CDM), construction safety has received greater attention. To measure the performance of safety on site, a mechanism is prerequisite to identify the elements of safety. In this industry, current measurement of safety performance is based on post-accidents such as fatalities, injuries and illnesses that are reported. Near misses, unsafe acts and no-loss accidents are not used as measures. Safety performance is more than just a measure of lack of safety but recognising its potential as an effective means of communicating positive safety results. This paper introduces the proposed methodology for developing an effective safety performance measurement tool.

Keywords: Measurement, proactive measures, reactive measures, safety performance.

INTRODUCTION

The frequency of accidents and loss or damage to property is of great impact to any organisation. Accidents cause delays and, both directly and indirectly, incur cost. A safer and more effective working environment can be achieved through proper management commitment, planning and establishment. In the period 1991/92-1995/96 figures for the fatal and non-fatal accident rate in the UK construction industry were as shown in Table 1.

Table 1: Fatal and non-fatal accidents for the construction industry from 1991/92-1995/96 (Employment Gazette 1991/92)

Type of acc	1991/92	1992/93	1993/94	1994/95	1995/96
Fatal	83	69	73	56	62
Non-fatal	17599	13474	11287	11504	10074

While there has been a reduction in fatal accidents this is accounted for mainly by the smaller workforce or less buoyant industry rather than improved standards. Traditionally accident statistics play an important role as a prime indicator of safety performance. Statistics alone tell little about how accidents occur or how to reduce the number of injuries. Accident statistics include fatality, lost time injuries (LTI), lost time accident (LTA); and sometimes but rarely near misses. Basically, only

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incidents that have been recorded are being considered. An accident report will provide factual information which is analysed at a later time to identify opportunities for improvement (Staley 1996).

A key factor in the control and improvement of any performance aspect on site is the ability to measure performance. Measurement will reveal performance levels; it will locate and identify problem areas; and make prediction for future accident problems. Safety performance measurement will be able to reflect the current safety state on site. In terms of measurement there is a need to change from measuring loss-type accidents to measuring potential accidents before they occur.

It is the purpose of this study to examine new approaches and techniques that will enhance safety performance measurement on construction sites. The paper will discuss the aims, objectives and reasons for this study. The author is still at the literature stage of the study and no primary data have been collected to date.

AIMS AND OBJECTIVES OF THE STUDY

The aim of this study is to develop a single measurement tool to measure safety on construction sites. This method will not only reflect the level of safety but will evaluate the effectiveness of safety performance; provide continuous information concerning changes in the safety state and enable identification of potential causes of future loss.

The objectives are:

1. To identify realistic and measurable proactive factors and sub-factors that affect safety performance on site.
2. To develop and test the measurement tool (SPMT) that will be a benchmark for future measurement.
3. To develop a measurement technique that will be able to tell not only how the accident occurred but also the remedial effort to be applied.
4. To be able to evaluate over time the degree of progress or retrogression of safety performance on site.

REASONS FOR THE RESEARCH

The construction industry has a poor safety record

The construction industry in comparison to other industries has not been a leader in site safety. It is known world wide for its poor safety record. The accident risk in the construction industry is about twice as high as other industries and the risk of fatal accidents are five times higher (Ngowi 1996). Nearly 30% of all workers who died in Britain in the 12-month period 1987-1988 were employees of one of the top 100 construction firms in the country (Barnard 1992). Clearly the accident rate is unacceptable and there is much more to be done regarding construction safety.

There are good reasons to want to improve safety performance

Safety should be managed like any other company function. Management should direct the safety effort by establishing achievable goals and planning and controlling them. Every accident is a reflection of the quality of management. This is emphasised in official reports such as on Piper Alpha and the King’s Cross Underground Station fire. The competence of management was criticised rather than their motives (Kletz 1993). A study by Liska (1993) showed that 90% of construction deaths were preventable and in 70% of cases lives could have been saved by positive actions of management. The construction industry is becoming more aware how important it is to have an effective safety programme. There are a number of contributing factors including:

- moral and legal obligations to provide a safe working place
- economic reasons of insurance premiums and the hidden or indirect costs of accidents (Hinze 1991)
- awareness by clients and contractors of the impact of safety performance on overall project costs (Rodriguez 1996)
- the adverse effect on contractor's reputation and unfavourable image for the client.

Although great strides have been made to reduce the number of accidents, further reduction is necessary. Legislation such as the Construction Design and Management 1994 Regulations (CDM), Occupational Health and Safety Act (OSHA) is only part of the safety framework. In the UK, safety legislation relies extensively on the concept of 'so far as reasonably practicable' and there is a need to give practical guidance and direction to those involved as to what constitutes of good safety practice (Anderson 1992). This legislation has helped to improve the safety performance on site but it alone is not enough. The industry needs an ongoing measurement of performance to continuously maintain safety on site.

Accident causation is complex but important

All accidents involve one or more events that lead to the accident and possible injury. The cause-result accident sequence can be summarised by the 'domino theory' developed by Heinrich (Figure 1). He was responsible for the 'non-injury accidents' concept. Heinrich defines this concept as an unintended event with potential to cause injury as well as damage to plant, equipment or material but which did not actually cause injury (Liska 1993).

Social environment → Fault of person → Unsafe act or condition → Accident → Injury or loss

Figure 1: Heinrich's domino theory (Liska 1993)

Heinrich estimates that as many as 88% of accidents could be attributed to unsafe acts (Mattila 1993). Shillito agrees with Heinrich's theory (Staley 1996). According to Shillito, accidents are rarely due to a single cause but to a number of causes that develop throughout the chain. Unsafe acts have the potential to become events with more serious consequences. Figure 2 clearly demonstrates that safety effort should be aimed at all accidents including unsafe acts and near misses rather than targeting the serious and fatal accidents at the top of the triangle. In theory, such practice will cause reduction from the base upwards. Factors such as nature of the work force, job site conditions and unsafe methods also contribute towards this poor performance as can be seen from Figure 3.

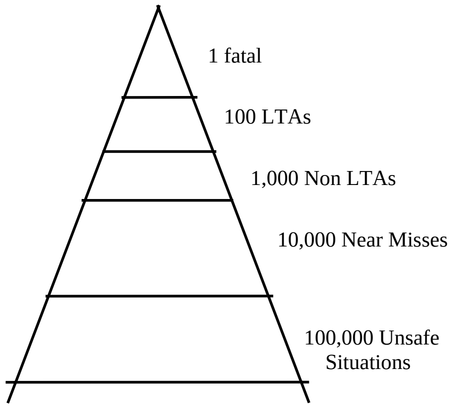

Figure 2: Unsafe situation to fatality pyramid (Smith 1991)

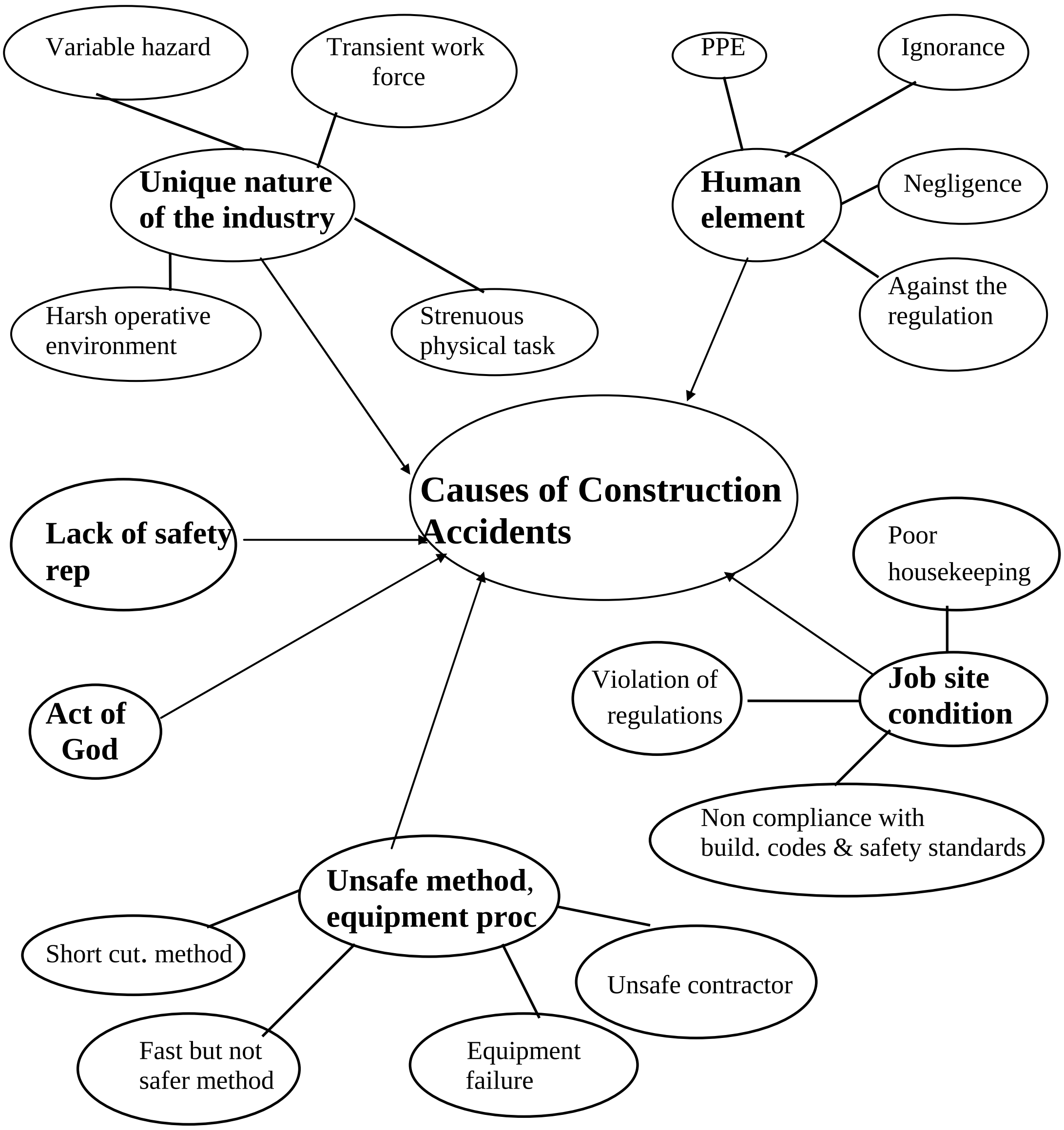

Figure 3: Causes of accidents (adapted from Bentil 1990)

There are good reasons to want to measure performance
Why is measurement important? Measurement is the backbone of any scientific approach to problem definition and solution. Tarrants (1980) defines measurement as 'a process that involves the assignment of numerals to objects or events according to rules or to represent properties'. With measurement we can qualify, order and quantify certain events and ultimately use the results as a basis for the control and prediction of actual performance. Measurement is prerequisite for control and prediction for future events.

Measuring performance against predetermined standards can reveal when and where action is needed to improve performance. Performance includes both 'hardware' (plant, premises, etc.), 'software' (people, procedures and systems) and individual behaviour (Anderson 1992). The question about measurement is: should measurement be expressed in terms of behaviour, tasks, traits or organisational outcomes? Should criteria be qualitative or quantitative?

Laufer (1986) defined the purpose of safety measurement as:

1. 'Determination of the reasons of success or failure.
2. Evaluation of the safety programme effectiveness at the site.
3. Location, identification of problem areas and determination of remedial efforts'.

There are many measurement systems but these systems do not work effectively
Most measurement systems such as OSHA, ANSI (American National Standard Institute), EMR (Experience Modification Rating), Lost Time Injury (LTI), Lost Time Accident (LTA) rely primarily on incidence or injuries whether disabling, medical treatment injuries or just first aid cases (Laufer 1986, Chhokar 1984). These are all post-accident appraisals that record the consequences of the problem rather than measuring or helping to prevent it. These approaches measure the lack of safety rather than the presence of safety (Tarrants 1980). Only data that are recorded are used. Near misses and unsafe behaviour are not noted even though they are well known causes of accidents. The majority of accidents are incorrectly classified because they are predictable and therefore not unexpected. Safety ought to be directed at the identification of hazards and the selection of timely remedial actions. Dependency on reactive measures does not give the true picture about the causes of accidents.

Proactive measures are better than reactive measures
The reactive or post-accident approach measures ill health and incidents. The reactive approach tends to be limited to the factual data about the victim such as the age, gender and occupation. This lacks factual information such as environmental conditions, task factors and behavioural factors. The reports only include activities which were directly and immediately involved in the accident. The failure to look towards understanding the factors thus limits the suitability. Even with a low reported accident rate, over a period of time, there is no guarantee that the site will be free from hazards. There is just no way of knowing. In such cases, statistics can be an unreliable, deceptive indicator of safety performance.

The reactive approach relies on reporting of accidents and the efficiency of reporting. There has always been a low level of reporting of accidents by employers. In 1990, level of reporting by employer is 34% and is predicted to be increasing only to 40% (Anderson 1992). The self-employed consistently report less than one in ten reportable injuries (Anderson). Furthermore, without proper training, reporting can produce in poor results such as missing of important data, difficulty in gathering data and consistency of data. There is also the problem of difference in definition of reporting. In a study by Clarke (1992) across the 12 European countries, there are different ways of reporting accidents. For example in the case of fatal accidents, the table below shows five different interpretations by the 12 countries. A fatal accident in Italy does not mean the same as in Spain or Portugal!

Table 2: Different definitions of fatal accidents by 12 European countries (Clarke 1992)

Fatal accident definition	Countries
Same day	Spain, Portugal
Up to 30 days	Netherlands
Up to 1 year	UK
No time limit	Denmark, Belgium, Germany, Greece, Ireland, Italy, Luxembourg
Varies in individual cases	France

Many studies and models have been developed based on this concept of unsafe behaviour and conditions (Satley 1996, Smith 1991). All these models agree that proactive measures or pre-accident measures are the answer to a better safety performance on site. Unlike reactive measures, proactive measures deal with data from current safety situations. The proactive measures provide essential feedback on performance before the injury or incidents occur. It involves compliance with performance standards and objectives and active participation of all levels of management. With proactive measures appraisal is constantly being carried out. The proactive approach is recommended as a sensitive and reliable indicator of safety performance and it must be able to;

- identify all contributing factors,
- indicate positive steps that can be taken by both management and workers,
- identify loss-potential problem at the no-loss stage,
- help predict, control and reduce accident losses (Chhokar 1984).

There are many forms of proactive measures such as;

- indirect monitoring where managers check on the quality and quantity of monitoring activities undertaken by their subordinates,
- procedures to monitor (weekly or monthly reports),
- periodic examination of documents to check compliance with standards,
- systematic inspections of site, plant and equipment,
- environmental monitoring,
- systematic direct observation of work and behaviour (Lindsay 1992).

There is a need for a single standardised measurement technique

Through the literature review, the author has identified at least 30 measurement techniques. Many of these are used in process engineering, mining and construction. All 30 measurement techniques are in-house safety systems. They design their own safety manuals and procedures. Figure 4 and 5 show all the measured factors.

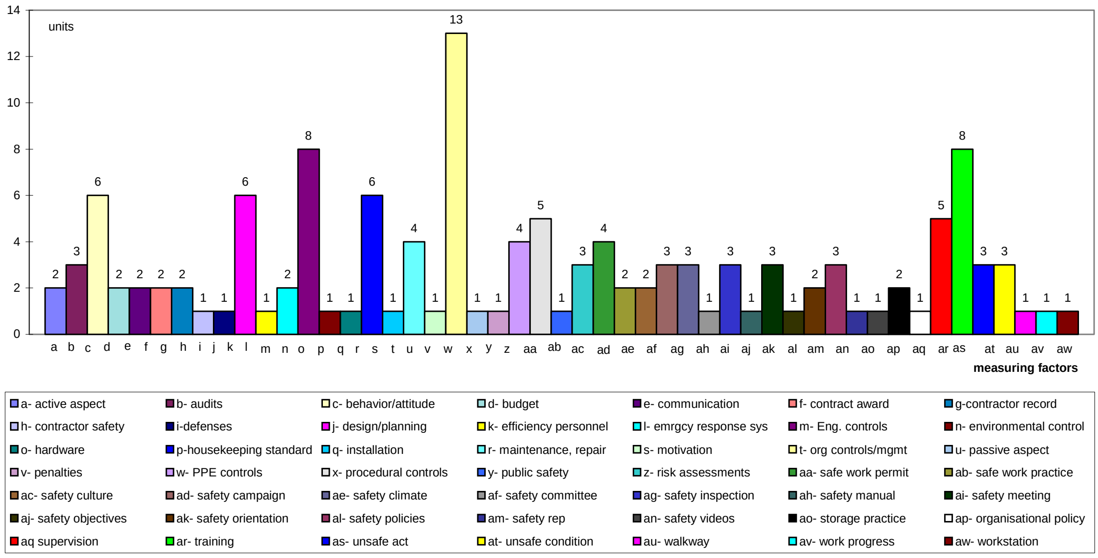

Figure 4: Proactive measures

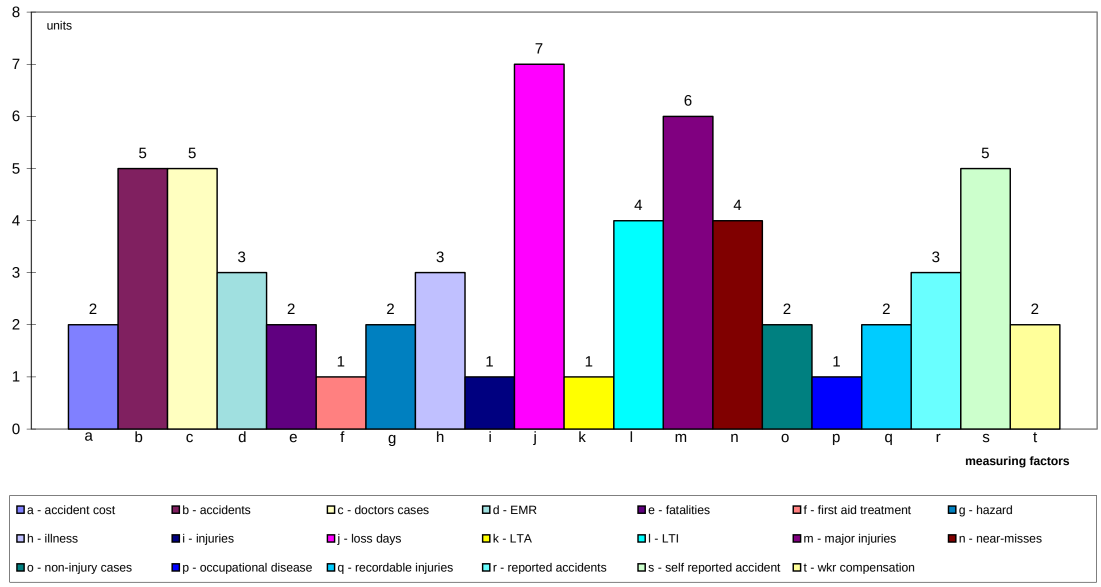

Figure 5: Reactive measures

Table 3: Highest score for reactive measures (5 scores and more)

Measuring factors	Units
Organisational/Management control	13
Engineering control	8
Training	8
Behaviour/Attitude	6
Design/Planning	6
Housekeeping	6
Procedural control	5
Supervision	5

These historic and contemporary SPMs have no consistent approach towards measuring safety performance. The findings reveal that there is a desperate need to design a single and common measurement tool that could be applied on any construction site. Figure 4 looks at the proactive measures while Figure 5 at the reactive measures. The vertical axis represents the number of times the same constituent criteria were found. For example, looking at Figure 4, there are 49 factors. The highest score is 11 and the lowest is 1. Table 3 shows the most frequent criteria based on the 30 measurement techniques. These eight criteria are essential for measuring safety performance and will form the basis for the SPMT. The author is currently evaluating the remainder of the criteria in Figure 4 to identify additional groupings for possible inclusion in the SPMT. The intention is to develop the SPMT with approximately 15 elements as 15 is a manageable figure to be measured on a busy site.

By having a single measurement tool, then the level of safety could be improved. The SPMT will be a benchmark towards measuring safety performance. The benefit of having a single technique is that it can compare the real progress between construction sites. The result will be easily understood and interpreted by the management, contractors and even the workers. The result will also be useful especially in rewarding good safety behaviour. The aim of this single technique is to continuously generate observable improvement in the way people work and will lead to a good safety culture. Measuring safety performance using accident data or reactive measures does not yield a true measure of safety. It was decided that a measure of safety using proactive measures would be the best strategy.

METHODOLOGY TO DEVELOP SPMT

The author will take the following steps to develop SPMT:

- Isolate the proactive measures from the literature reviews.
- Design conceptual framework on all the proactive measures based on Figure 4.
- Divide into factors and sub-factors.
- Conduct a ‘dry run’ to verify the reliability of SPMT.
- Receive feedback and develop further before sending out to a bigger sample.
- Receive feedback, review and conduct interviews and workshops to stimulate discussion regarding SPMT.
- Conduct the final test on SPMT.
- Analyse and tabulate the data. Compute the percentage of safety improvement.

CONCLUSION

The author intends to design a common safety performance tool to measure safety on site. The author has identified the reasons to undertake the study. The industry has a poor safety record and accident causation is important but complex. There is a need to measure safety performance, but currently the many techniques make useful comparison difficult. SPMT will aim to move the industry away from a purely reactive response towards a more proactive approach to the improvement of safety performance. This approach, if successful, will contribute to changing the culture of the construction industry with regard to safety.

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