First International Conference on Construction in the 21st Century (CITC2002)
"Challenges and Opportunities in Management and Technology"
25-26 April, 2002, Miami, Florida, USA

THE PERFORMANCE APPROACH TO CONSTRUCTION WORKER SAFETY - A MODEL FOR IMPLEMENTATION

Theo C. Haupt
Senior Lecturer, Peninsula Technikon, Bellville, Western Cape, South Africa

ABSTRACT

A procedural model for implementing the performance approach was developed after an extensive review of the literature on the performance approach as it applies to building construction, and approaches advocated in safety and health legislation in several countries. The model promotes the resolution of planning issues ahead of organizational ones. In this case, planning is the determination in advance of the safety objectives of the organization and deciding upon the course of action that will most effectively achieve those objectives. The model fosters a proactive approach since management and workers are involved on a participatory basis in setting the safety objectives to be achieved with respect to each activity before it is undertaken. In this paper, the procedures required to implement the performance approach to construction worker safety are presented and outlined within the framework of the model.

KEYWORDS

Performance Approach, Planning, Risk Assessment, Safety Objectives, Hazard Identification

1. THE PRESCRIPTIVE MODEL

The traditional prescriptive approach described in Figure 1, prescribes the means to execute a construction activity in a safe and healthy manner. Non-compliance with prescriptive standards is dealt with punitively, usually by means of fines levied against the employer. This approach (also known as the command-and-control approach) has largely relied on formal rules, procedures and the policing of workers to ensure compliance (Human Performance Technology (HPT, 1998). Many of the standards are vague. Others are very specific. Although not practically possible, the approach attempts with prescriptive regulations to cover every possible situation in construction. Revisions of standards are on going and often tedious and time-consuming. These revisions arise from new knowledge and technology that need to be incorporated. Further, prescriptive standards are usually written in legal terminology rendering them difficult to interpret.

In many cases employers are aware of a violation. However, they do not possess the knowledge to correct the hazard in order to comply with the prescribed provisions. This prescriptive form of legislation has become the norm in many countries where occupational safety and health legislation has been introduced. Unsafe acts are generally accepted to be the major contributing cause of accidents. Prescriptive safety legislation is primarily aimed at unsafe conditions. Enforcing this type of legislation will not completely eliminate or adequately reduce unsafe acts. This regulatory approach has tended to evolve into a reactive rather than proactive one.

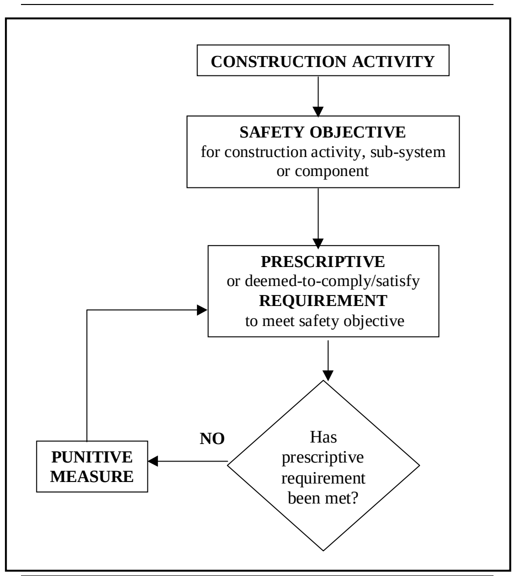

Figure 1: Traditional Prescriptive Model

2. THE PERFORMANCE MODEL

A procedural model for implementing a performance approach to worker safety and health by contractors on construction sites is depicted in Figure 3. The model has been developed from an examination of the approaches advocated in Australia, New Zealand, Europe and the United Kingdom. It promotes the resolution of planning issues ahead of organizational issues. Planning, in this case, constitutes the determination in advance of the safety objectives of the organization. The course of action is decided upon that will most effectively achieve those objectives. The model fosters a proactive approach. Management and workers are involved in setting the safety objectives to be achieved for each activity before it is undertaken. Further, the model does not conflict with the clients' responsibility for worker safety under legislation such as the Construction (Design Management) Regulations in the U.K. and the various hybrids of Directive 92/57/EEC in Europe. In particular, the roles are unaffected of the planning or project supervisor, and the various safety and health coordinators. The requirement to produce project-specific safety and health plans and files also remains unaffected. The model is somewhat similar to the industrial engineering solution delivery process depicted in Figure 2 that can be conceptualized as a series of steps that are repeated.

The main procedures involved in the model in Figure 3 are outlined as follows:

2.1 Classify Construction Activity

In particular, the following information about each construction activity should be gathered as part of the classification process:

- Duration and frequency of the tasks involved;
- Location of the work;
- Number and trade category of workers that will execute the work and be exposed;
- Other parties that might be affected and exposed by the work;
- Training which workers had received about the tasks to be carried out;
- Written systems of work and/or permit-to-work procedures prepared for the tasks, where these exist;
- Plant, equipment, powered hand tools and machinery that may be used together with manufacturers' or suppliers' instructions for their operation and maintenance;
- Size, shape, surface nature and weight of building materials that might be handled to complete the tasks;
- Distances and heights that building materials have to be moved manually;
- Nature, quantity, physical form and hazard data sheets (MSDSs) of substances used or encountered during the tasks;

- Requirements of legal acts, regulations and standards relevant to the work being done, plant and machinery used, and substances used or encountered;
- Examination of the firm's control measures already in place; and
- Firm's incident, accident and ill-health experience associated with the work being done, and plant, equipment and substances used (adapted from British Standard 8800:1996).

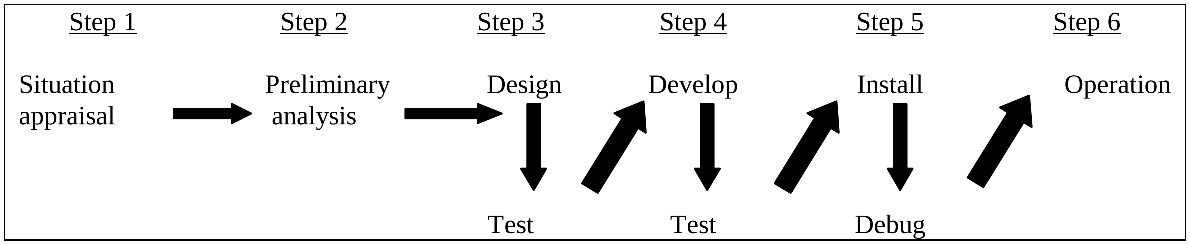

Figure 2: Solution Delivery (adapted from Sink and Morris, 1995)

2.2 Risk Assessment

The contractor initially assesses the risks subjectively associated with each construction activity, assuming that planned or existing controls are in place. Risk refers to the likelihood that an accident might occur and severity of the consequences of having an accident (British Standard 8800:1996). A specialized safety professional employed by the contractor could carry out the assessment. The determination of the severity or tolerability of the risks associated with the particular activity will be based on either the contractor's own experience or the experience of the industry. Severity of the risks will determine the level of resources that the contractor needs to allocate to reduce the risks themselves, and the exposure of workers to them. In particular, risk assessment needs to be carried out for situations where hazards appear to pose a significant threat and it is uncertain whether existing measures are adequate. By using a participatory approach, management and workers agree safety procedures based on shared perceptions of the hazards and risks (British Standard 8800:1996).

A risk assessment pro forma used to record the findings of an assessment effort should, for example, cover:
- Details of the work activity;
- Hazard(s) and/or potential hazards;
- Controls in place;
- Levels of risk; and
- Action to be taken once the assessment is completed (British Standard 8800:1996).

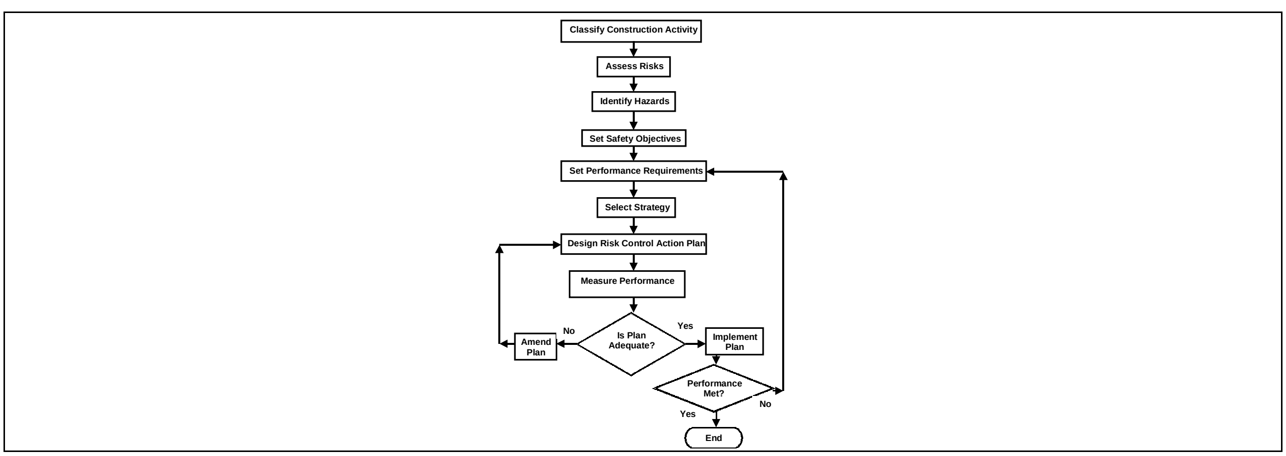

Figure 3: Procedure to Implement the Performance Approach to Worker Safety on Construction Sites

Procedures for making an informed determination of risk have to be developed. Examples of these include safety reviews, checklists, what-if-analysis, failure mode and effects analysis, and cause-consequence analysis (Stavrianidis, 1998). Further, criteria have to be established for deciding whether risks are tolerable where the risk has been reduced to the lowest level that is reasonably practicable.

A simple risk assessment model is illustrated in Figure 4. In this model the likelihood or probability of an accident occurring while a task is carried out and the severity of the accident should it occur are determined before the task is executed. If the risk is acceptable, the task proceeds. If the risk is considered unacceptable and change is not possible, the task is restructured. Where change is possible, the probability and/or the severity is reduced. In either case, the acceptability of the risk involved in the task is measured before it proceeds.

An alternative way of assessing risk is represented in Figure 5, adapted from Statzer (1999), where one axis represents the likelihood of a risk occurring and the other its expected cost. It is likely that by using such a matrix, construction firms may discover that they are allocating resources on potential risks that are extremely unlikely, while ignoring less-costly risks that may occur at any time.

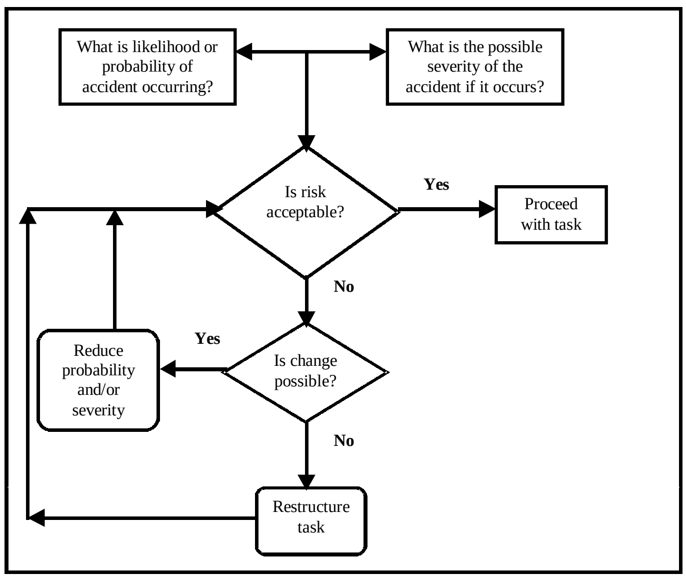

Figure 4: A Simple Risk Assessment Model

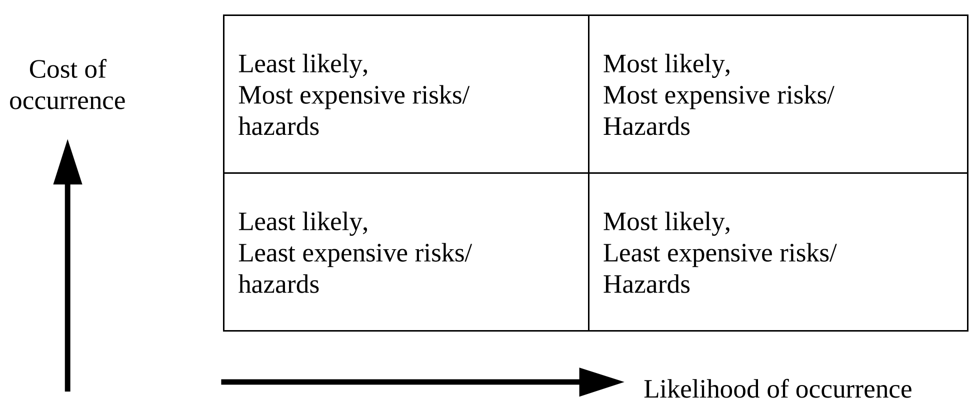

Figure 5: Evaluating Relative Risks/Hazards

The severity of harm needs to be considered with respect to the part of the body most likely to be affected. The nature of the harm could range from slightly harmful to extremely harmful. An example of an estimator of the level of risk is provided in Table 1.

Table 1: Estimator of Risk Level

	Slightly harmful	Harmful	Extremely harmful
Highly unlikely	Trivial risk	Tolerable risk	Moderate risk
Unlikely	Tolerable risk	Moderate risk	Substantial risk
Likely	Moderate risk	Substantial risk	Intolerable risk

The action that should be taken with respect to each of the risk levels indicated in Table 1 as adapted from British Standard 8800:1996 is suggested in Table 2. The identification of the level of risk will result in the development and implementation of suitable prevention and protection strategies (Lan and Arteau, 1997)

Table 2: Action in Respect of Risk Levels

Risk level	Action and timeframe
Trivial	No action is required and no documentary records need to be kept
Tolerable	No additional controls are required. Consideration may be given to a more cost-effective solution or improvement that imposes no additional cost burden. Monitoring is required to ensure that the controls are maintained.
Moderate	Efforts should be made to reduce the risk, but the costs of prevention should be carefully measured and limited. Risk reduction measures should be implemented within a defined time. Where the moderate risk is associated with extremely harmful consequences, further assessment may be necessary to establish more precisely the likelihood of harm as a basis for determining the need for improved control measures.
Substantial	Work should not be started until the risk has been reduced. Considerable resources may have to be allocated to reduce the risk. Where the risk involves work in progress, urgent action should be taken.
Intolerable	Work should not be started or continued until the risk has been reduced. If it is not possible to reduce risk even with unlimited resources, work activity has to remain prohibited.

In the case of both tables, a risk that is "tolerable" is taken to imply that the level of risk associated with the construction activity has been reduced to the lowest that is practicable.

2.3 Identify Hazards

All the significant hazards related to each construction activity should be identified. In particular, consideration should be given to which workers will be exposed and what the consequences of such exposure might be. Methods to identify and categorize hazards have to be established. For example, a hazard prompt list might be developed taking into account the nature of the work activities of the organization and locations where work is carried out. Examples of such lists are contained in both the guideline documents to safety legislation in the U.K. and New Zealand.

2.4 Set Safety Objectives and Performance Requirements

Objectives or user (worker) requirements should be specific, measurable, achievable, relevant and timely. Once key objectives have been selected, they need to be quantified. For example, objectives to increase or reduce something should specify a numerical figure and a date for their achievement; objectives to introduce a safety feature or eliminate a specific hazard should be achieved by a specified date; and objectives to maintain or continue existing conditions should specify the existing level of activity (British Standard 8800:1996). Additionally, appropriate performance requirements and outcome indicators that should be quantitative, need to be selected to indicate the extent to which the safety objectives have been achieved. It is also necessary to measure the situation before the implementation of a safety plan, also known as the baseline. An example of a safety objective associated with the performance requirement to prevent falls from scaffolds is shown in Table 3.

With respect to duty of employers in relation to heights at some workplaces, the New Zealand regulations require that every employer shall take all practicable steps to ensure means are provided to prevent the employee from falling. This provision is covered under clause 21 that deals with heights of more than 3 meters (9'). It applies to every place of work under the control of that employer where any employee may fall more than 3 meters. Employers must ensure that any means provided to prevent employees from falling are suitable for the purpose for which they are to be used.

Table 3 An Example of a Safety Objective to Prevent Falls from Scaffolds

Quantified key objective	Increase the usage rate of guardrails, toe boards and tying off on all scaffolds from the present (measured) value of 50% to 100% on this job
Performance requirement	A guardrail 35”-43” above the walking platform must be erected along the exposed edge of all scaffolds A mid-rail must be incorporated A toe board must be included All workers on scaffolds over 9’ high must wear individual fall arrest systems such as lanyards and static lines
Outcome indicator	Records of observed usage of guardrails, toe boards and individual fall arrest systems on scaffolds

2.5 Select Strategy To Meet Performance Requirements

There are several possible strategies that could be used to meet the performance requirements and the safety objectives that have been set. These are outlined in Figure 6.

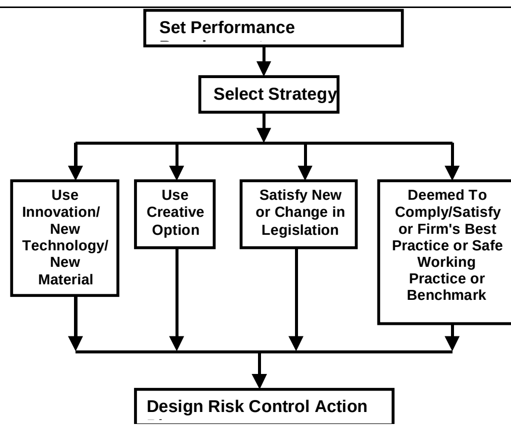

Figure 6: Possible Strategies to Meet Performance Requirements

In the example in Table 3, the contractor had several options with which to ensure that the safety objective was met of preventing falls from scaffolds - all of which would have satisfied the requirements of the performance-based regulations. The contractor could have used:

- New method;
- Newly developed individual fall arrest system;
- Innovative patented scaffolding system;
- Improvement to existing work practices within the organization; or
- Established industry or company safe working practice.

In this example, the contractor selected the last option since the use of guardrails, toe boards and tying off was already an established practice both within the firm and the industry at large. However, the usage needed to be increased from the present value of 50% to 100% on the particular job.

2.6 Design Risk Control Plan and Select Method of Measuring Performance

Contractors can do both the steps of designing the risk control plan and selecting the method of measuring performance at the same time. The latter step is the equivalent of verification in the basic performance models described earlier.

A plan to control the risks associated with the construction activity needs to be designed. The risk control plan specifies who will do what, by when, and with what result (British Standard 8800:1996). For its success, the plan must of necessity enjoy the support of top management (Cook and McSween, 2000; Petersen, 1996). Further, it should be fully costed and have adequate financial resources allocated for its implementation. The plan should be implemented in accordance with the performance requirements and outcome indicators decided upon to achieve the key safety objectives. An example of the broad elements of a risk control plan for preventing falls from scaffolds is reflected in Table 4.

Trends in the outcome indicators should be monitored continually throughout the implementation period of the plan. The adequacy of the plan needs to be continually evaluated and the plan amended as required. The cost effectiveness of the safety objectives and the risk control plan should be reviewed to determine which elements of the plan contributed to its success. Those, which were unnecessary, may then be eliminated.

Table 4 Risk Control Plan to Prevent Falls from Scaffolds

Gain commitment from top management
Agree on a budget for implementing the performance requirements
Train workers, foremen and supervisors in the required method of erecting scaffolds
Train workers in the proper use and maintenance of individual fall arrest systems
Frequent observations and inspections to check that scaffolds have guardrails, mid rails, and toe boards and that workers are tied off and using individual fall arrest systems correctly

In Table 5 adapted from British Standard 8800:1996 attention is drawn to the likelihood that an objective may be achieved even though the control plan failed to be implemented.

Table 5 Review of Risk Control Plan

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Was control plan implemented?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td rowspan="2">Was objective achieved?</td><td>Yes</td><td>No corrective action required, but continue to monitor</td><td>Plan was not relevant. Find out what has led to the achievement of objective</td></tr>
<tr><td>No</td><td>Plan is not relevant, therefore prepare a new plan</td><td>Make renewed effort to implement plan; continue to measure outcome indicators</td></tr>
</table>

Contractors have several methods that they could use to measure whether the action plan was effective and whether the performance requirements have been met to satisfy the safety objectives for the particular task. These include:

- Checklists;
- Inspections;
- Safety samplings;
- Benchmarking;
- Environmental sampling;
- Attitude surveys;
- Behavior sampling;
- Walk-throughs;
- Document and record analysis; and
- Expert and consultant involvement.

For the example in Table 3, recording the results of regular observations was selected as the outcome indicator and would be appropriate to determine whether the performance achieved the safety objective.

2.7 Review Adequacy of Risk Control Action Plan and Measuring Performance

The final stage in the implementation process is the review of the performance requirements by measuring the outcome indicators to determine whether the control plan was effective and the safety objectives achieved. Where the performance requirements were not met, new performance requirements might have to be established. In this event, different outcome indicators might have to be decided upon. It is also likely that a new or revised risk control plan might have to be drawn up, the plan implemented, the outcome indicators measured until the performance requirements have been met, and the safety objectives achieved. Should the review indicate that the safety objectives for the particular construction activity have been satisfactorily and cost effectively achieved, the performance solution selected might become an organizational safe working practice to be prescriptively followed on all future projects for that activity.

3. CONCLUSION

The procedures presented in this paper have been developed from safety and health approaches advocated in Australia, New Zealand, Europe and the United Kingdom. The model promotes a proactive approach in which management and workers are jointly involved in setting safety objectives before construction activities are executed. In particular,

- All construction activities are classified;
- All the associated risks are assessed;
- All significant hazards are identified;
- Appropriate and clear safety objectives are set;
- Specific performance requirements are quantitatively agreed upon;
- Appropriate strategies to meet these requirements are selected;
- The risk control plan is designed;
- The methods for measuring performance are chosen;
- The predetermined outcome indicators are measured; and
- The adequacy of the risk control plan is reviewed.

The model resolves planning issues ahead of organizational ones. It is this proactive feature of the model that has the most potential to improve the safety performance of construction companies in the 21st Century.

4. REFERENCES

British Standard 8800 (1996). *Occupational Health and Safety Management Systems*

Cook, S. and McSween, T.E. (2000). "The role of supervisors in behavioral safety observations," *Professional Safety* – Journal of the American Society of Safety Engineers, vol. 45, no. 10, pp. 33-36

Human Performance Technologies (HPT). (1998). "Start a Behavioral Safety Program—Performance-based Safety Programs." http://qhpt.com/behavioral_safety.html, 09/16/01.

Lan, A. and Arteau, J. (1997). "Limits and difficulties in applying the Quebec safety Code for the Construction Industry—The case of excavations," In Ratay, R.T. (ed.), *Construction Safety Affected by Codes and Standards*, Proceedings of a session sponsored by the Design Loads on Structures During Construction Standards Committee and the Performance of Structures During Construction Technical Committee of The Structural Engineering Institute, Minneapolis, 5-8 October, pp. 16-34

Petersen, D. (1996). *Human Error Reduction and Safety Management*, New York, Van Nostrand Reinhold

Stavrianidis, P. (1998). "Reduce risk with performance-based safety standards," *Hydrocarbon Processing*, vol. 77, no. 10, pp. 91-95

Statzer, J.H. (1999). "An integrated approach to business risk management," *Professional Safety* – Journal of the American Society of Safety Engineers, August, pp. 30-32