

Construction productivity and risk management in Singapore

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In many managers' minds, productivity and safety are opposites of each other. Risk management (RM), being closely associated with safety and a mandatory requirement activity for all workplaces in Singapore, is thus considered almost anti-productivity. This misperception is all the more prevalent in the construction industry which is the most hazardous as well as one of the most sensitive to productivity disturbances.

Nothing could be further from the truth. The myth that RM and productivity are counter to each other has been dispelled by many investigators in many countries. In a recent publication [Ref 1], the positive impact of safety on productivity has been clearly established, as depicted in Figure 1.

The Occupational Safety and Health Administration (OSHA) of USA goes so far as to state [Ref 2], "In fact, an effective safety and health program forms the basis of good worker protection and can save time and money (about \$ 4 for every dollar spent) and increase productivity and reduce worker injuries, illnesses and related workers' compensation costs".

In his many training courses, seminar talks, and conference presentations, the author has discussed, deduced, and presented a number of safety considerations which influence construction productivity in Singapore. Chief among them are the proper application and use of risk assessment and control, and the need for improved and increased supervision, as described in the following sections.

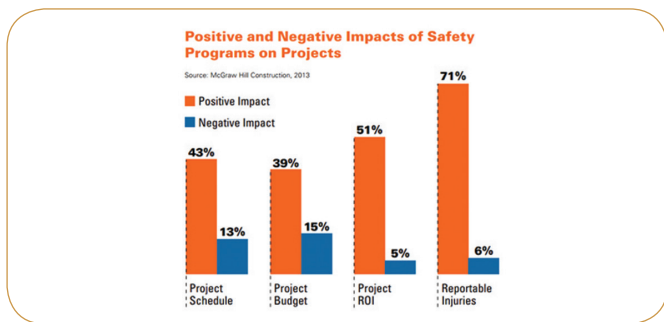


Figure 1: Impact of safety on productivity

SAFETY AND PRODUCTIVITY

Correlation between Safety and Productivity

A recent analysis of a Foster Wheeler Energy UK Ltd study [Ref 3] identified inter-relationships between four factors that affect the success of construction projects:

1. Cost Ratio = Budget Cost / Actual cost
2. Schedule Ratio = Planned Duration / Actual Duration
3. Safety = Millions Man-hours / No of Lost Time Injuries
4. Productivity Ratio = Budget Man-hours / Actual Man-hours

From these, the second statistically highest positive association was found to be between Productivity and Safety with Correlation coefficient R^2 of 0.63 (ie R of 0.79).

As shown in Figure 2, a doubling of safety, ie halving of accidents, could result in an increase of about 12% in productivity.

This need not be surprising because as Table 1 would show, there are many similarities and parallels between safety and productivity.

Safety	Productivity
Address risks at source	Find the root cause and resolve it
Be proactive, not reactive	Anticipate problems and plan ahead
Be performance-oriented, not prescriptive	Take any steps necessary to save the bottom line, namely productivity
Distribute responsibility to all stakeholders	Must satisfy all shareholders, team work very critical
Penalties for violations increased	Penalties immediate and harsh, a matter of survival

Table 1: Similarities between safety and productivity

Both safety and productivity involve the same parameters and aims:

- Same attitudes, techniques and methods
- Same characteristics as regards supervision and inspection
- Same management actions (planning, training, communication, measurement and control)
- Same physical actions (housekeeping, site layout, traffic flow, and adequate access)
- Same process of working out what could go wrong, and determining its impact and measures to reduce its occurrence

Further, there are many common elements and linkages between safety and productivity:

- Co-operation between management and employees
- High-quality working environment
- Employees' challenge, responsibility and job autonomy
- Development of new working methods and equipment to improve ergonomics and decrease strain
- Cost interaction between safety and productivity

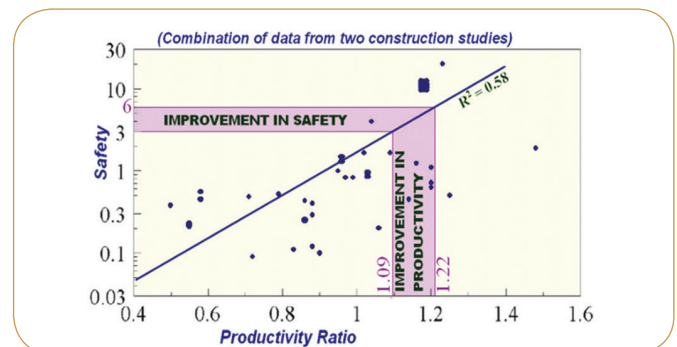


Figure 2: Results from two construction studies

Advantages and benefits of safety to productivity

It has been determined that improving safety, apart from increasing productivity will offer the following advantages:

- Increase the physical and psychological well-being of the workforce
- Decrease absenteeism and 'presenteeism' (being physically present but professionally ineffective)
- Improve morale and employment relationships, and enhancement of employees' desire to work
- Improve human performance
- Produce higher profits.

Documented direct benefits include the following:

- Reduced insurance and workers' compensation premiums
- Reduced litigation costs
- Reduced sick pay costs
- Lower injury/illness costs
- Fewer production delays
- Reduced product and material damage
- Improved production and productivity rates
- Fewer injuries mean that more people keep working
- Designing safety into business increases innovation, improved quality and improved efficiencies
- Safe workplaces enhance corporate reputations and improve staff recruitment and retention

Indirect benefits include:

- Improved corporate image
- Reduced staff turnover
- Increased chances of winning contracts, job satisfaction / morale etc

Problems with Poor Workplace Health and Safety

The converse of what has been said thus far also is true. Poor workplace health and safety leads to poor productivity. Examples of poor workplace health and safety practices that lead to poor productivity include:

- Unhealthy physical and/or mental stress
- Too few breaks
- Badly designed or outdated equipment
- Poor lighting or ventilation
- Uncomfortable seating
- Poor supervision
- Poor job design
- Lack of worker participation

It is rare to find an organisation with high levels of health and safety and low productivity. But there are many with low levels of health and safety whose performance in productivity is also bad.

The most powerful argument for safety versus productivity can easily be made through the business case. While it is true that the majority of companies do not have accidents, it is equally true that no company can claim to be immune from the next

accident. A company's 'clean' or 'perfect' safety record of 'x' number of years is valid only until the next accident – which could be tomorrow (unless today is still not over)!

Examples abound.

It is easy to show how, for lack of a ten-dollar pair of safety glasses, a company can spend \$ 5000 on medical fees alone on the grinder whose eye received a metal splinter, with the actual total cost soaring to about five times as much and totalling \$ 25,000, and hence having to do business of about half a million dollars (assuming a 5% net profit margin) to recover the expenses from profit.

It would be superfluous to point out that even a rudimentary risk assessment would have highlighted the folly of allowing a machine grinder to work without safety glasses.

The common presumption that accidents happen only to the stupid people next door, and it will never happen to us, must go!

Why the benefits of safety are not recognised

Among the reasons for safety benefits not being recognised, particularly by management, are the following:

- Employers typically underestimate the cost of an occupational health and safety problem while overestimating the costs associated with its remedy.
- The cause-effect relation between safety and benefit is often not straightforward. This difficulty is complicated by the fact that typically, several initiatives will be implemented at the same time (not only health and safety actions, but also human resource actions), which makes it difficult to link a specific initiative to a specific outcome, such as increased productivity leading to increased profits.

The author likens investment in safety to the planting of a fruit tree. The tree may take a long time to bear fruit, so that there can be no immediate or even annual expectation or return on investment (ROI) – a lot of patience may be needed. Another equally important outcome of this metaphor is the likelihood of the fruit tree dropping a fruit into the neighbour's yard, so one must be prepared to accept the benefit of safety investment not being exclusive to the investor – but then, it would be equally likely that the neighbour's tree would drop a fruit into the investor's yard!

Management therefore tends to get frustrated that the safety committee cannot show what the investment of 'x' dollars in risk management got for the company, except the fulfilment of government regulations. It is easy to show how much an accident cost, but it is almost impossible to prove how many injuries and fatalities did not happen because of the investment. Proof will come only with the improvement of the company's accident and incident statistics over a period of two or more years, and cumulatively with the improvement of the industry's and national statistics over a period of time.

The message to remember? Safety benefits are often invisible and intangible, but with patience, caring and sharing, safety benefits will indeed show up in due course.

RISK MANAGEMENT AND PRODUCTIVITY

Dynamic risk matrix

With the role of safety in productivity understood, the contribution of risk management to safety and hence to productivity should be easy to establish.

In Singapore, as of now, risk management is an absolute necessity by every employer in every workplace. Yet, most of the time, the process is done only because it has been mandated, and generally as a paper exercise, to be done once every three years and then the documents put away until the next deadline, or until the next deadly accident.

What is not realised, or if known, easily forgotten, is the fact that risk assessment is the only practical leading indicator of safety, all accident investigations and case studies being lagging indicators, after the fact.

As is well known, risk management consists of three essential steps:

- Hazard identification
- Risk assessment from likelihood and severity
- Risk control by established hierarchy

Of the three, the first one of hazard identification is the key to the success of the entire process. A hazard not identified is a hazard unknown, immeasurable, and uncontrolled.

Most accident investigations by Ministry of Manpower (MOM) in Singapore are tagged with the violation risk assessment 'not done' or 'inadequate'. Invariably, the cause of the accident is one which the risk assessors of the organisation failed to identify. Once a potential danger is identified, it is a short and straight path to find and implement its elimination or mitigation.

Here, the author can speak from personal experience of (a) training thousands of engineers through hundreds of courses over the last 15 years in Singapore, (b) certain consultation and expert witness assignments, and (c) research projects carried out on behalf of the government and personally. Many, if not most, treat the risk matrix as a necessity imposed by government regulations, to avoid fines and other penalties.

In truth, risk assessment is a strategy to improving safety, and its outcome is a dynamic, evolutionary road map, worth continuous or frequent attention and revision.

Once the attitude that risk assessment is a paper exercise to satisfy MOM is given up, and the true value of the risk matrix is appreciated, the scenario can change dramatically.

Various uses of a risk matrix

The author has always insisted that the risk matrix has many uses and it would be for the risk assessor to use it to most effect. He has dealt with this in detail in his book [Ref 4].

Consider nine activities with hazards, having various levels of likelihood and severity, assessed to be in one of three categories of risk as shown in Table 2.

Conventionally in Singapore, risks are represented in a risk matrix, of 3x3, 5x5 or other convenient size. Figure 3(a) depicts the simplest 3x3 qualitative matrix, with the nine job steps marked on it.

As status map

The first and most obvious use of a risk matrix is that it is a status map, a visual cue to the magnitude and location of various risks in a particular job or phase of the project [Figure 3(a)].

- The presence of risk markers on the 'High' ('Red') risk zone of the matrix focuses action to eliminate or alternatively reduce them to at least 'Medium' ('Yellow').
- Their concentration in the 'Medium' zone, while not necessarily meaning that the job is dangerous, indicates the need for effective control and careful inspection, maintenance and supervision regimes.
- Their exclusive presence in the 'Low' ('Green') region, may be quite comforting to the safety committee and the management, but may also result in complacency and neglect of needed monitoring and a care regimen.

Step No.	Likelihood	Severity	Risk category
1	Low	Low	Low
2	Low	Medium	Low
3	Medium	Medium	Medium
4	Medium	High	Medium
5	High	High	High
6	Medium	Medium	Medium
7	High	Low	Medium
8	High	High	High
9	Low	Low	Low

Table 2: Case study of risk assessment

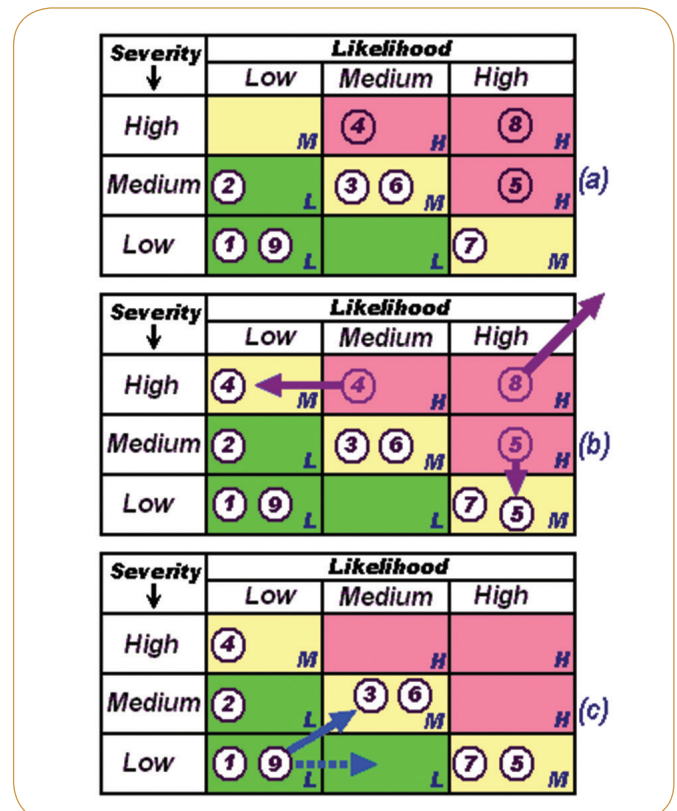


Figure 3: Uses of risk matrix

As a decision tool

The second use is in the decision-making process. High risk activities such as 4, 5, and 8 must be brought down to at least Medium level before the job can proceed.

As shown in Figure 3(b), a High risk may be mitigated, that is, lowered, by decreasing its likelihood, say, from Medium to Low, as shown by the arrow for 4, or by decreasing its severity say from Medium to Low, as shown by the arrow for 5, or by a combination of reduction of both likelihood and severity – which is not as easy as it sounds!

This mitigation may be done by substitution, engineering control, administrative control, or Personal Protective Equipment (PPE).

On the other hand, there may be cases like activity 8 which cannot be brought down in likelihood and/or severity sufficiently to lower its level to Medium, within the resources available to the company. The wise way to handle this problem is to subcontract that step to a specialist who will not only be able to take care of the task well, but who will be competent to manage the associated risks. This corresponds to 'elimination' of the risk, which would be the most effective control, taking it out of the parent company's risk matrix once and for all.

Although these actions may be done without the risk matrix, the matrix visually dramatises the need, marks the direction of desirable action, and tracks the outcome.

As pro-active warning system

It is a wise idea to check the risk status of a job at regular intervals, shorter than once in three years, as is the current practice. Of course the RM Regulations and Code of Practice require revisions after every accident or major incident, major changes in product, process, management etc, but since these happen only to a small fraction of functioning companies, most companies end up doing the risk assessment exercise only once in three years.

The author used to advocate at least annual updating as corresponding to budget changes and needs. But the latest Code of Practice for Risk Management advocates checking the risk assessment every month.

That would be very good, because nothing remains constant at an industry workplace. Machines wear out, people get negligent, and systems deteriorate. These would often happen gradually, without visible or audible warnings, unless someone specifically looks for brewing trouble.

The frequent updating of a risk matrix can highlight the shifting of an activity from Low risk to Medium risk, or what is worse, from Medium risk to High risk, without the safety group noticing it.

If upon a routine check, activity 9 was found to have gone from Low to Medium as shown in Figure 3(c), although 'Medium' risk is 'tolerable', it would need immediate investigation and fresh controls to bring it back to Low risk.

Even a horizontal shift, as shown by the dotted arrow in Figure 3(c), would be a red flag of warning, although the level of risk

has not changed and remains Low. The point here is that the shifted position of activity 9 (with Risk Index 2) is one level worse in likelihood than its original position (with Risk Index 1), and the committee or group concerned should look into the cause, sooner the better, so that the situation may be controlled before the risk scenario gets worse.

Even looking at the situation optimistically, it is quite likely that a hazard that had been estimated High and brought down to Medium happens to further sink to Low, or a Low with Risk Index 2 might descend to a Low with Risk Index 1, which might mean that some expensive controls may be slackened to bring it back to its original manageable level.

Other uses

Experienced and smart risk analysts can find other uses for the risk matrix.

If the assessment is conducted at regular intervals, say a month apart, changes in the risk matrix may be plotted (or quantified and computed) as a tracking mechanism to predict future changes, by way of statistics and trend-lines.

Risk matrices from different jobs or for the same job from different sites may be compared to obtain a company-wide or industry-wide picture.

New techniques such as BIM actually enable managers to combine and efficiently implement risk management and productivity improvement.

RISK MANAGEMENT OF PRODUCTIVITY FACTORS

Construction productivity in Singapore is known to be an amalgam of many factors, such as the following:

- Equipment, tools, and services
- New technology and mechanisation
- Labour force and training
- New materials
- Role of management
- Communication

As every one of these factors is heavily risk oriented, addressing the risks should automatically improve productivity.

Equipment, tools, & services

Inadequate or inefficient equipment, ineffective tools, and inappropriate services can drastically cut into productivity.

With frequent breakdowns and long-term production losses, residual risk will shift from low to medium and from medium to high, inevitably causing delays or stoppage of work, adversely affecting productivity. Regular or on-demand risk assessment will catch these deviations in time, and productivity can be maintained.

In the long run, continuous evaluation and upgrading of equipment, tools and services may reduce risk and increase productivity, making the effort and cost worthwhile. As example may be cited the change from 220 v to 110 v for power tools at site which will reduce the risk levels (eg of electrocution) and control costs, and thus improve productivity.

New technology and mechanisation

New technology involves new materials, new equipment, complex processes, and fresh or updated training, requiring from workers a higher level of technical expertise, and/or smarter and faster reaction.

Each item in the list above will increase the risk level, and/or bring in fresh risks which will affect productivity. These increased or new risks must be identified, assessed, and addressed properly before improvement in productivity can be ensured.

Mechanisation of site activities such as concrete screeding, rebar binding with wire, and concrete breaking will considerably enhance productivity.

But these benefits can be reaped only if and when the risks of the new high-tech equipment and the concomitant requirements for extra training and supervision are evaluated and managed.

An example here would be that many high risks of in-situ concrete such as working at height and manual handling of heavy loads can be eliminated by precast components or entire precast units, while improving productivity. However, precast concrete also brings with it new risks such as crane handling of very heavy loads, apart from the higher costs.

On the other hand, most of the new or increased risks may be addressed with re-training of the work crew and streamlining of many site operations – again as envisioned in a properly planned risk management.

Labour force and training

Singapore's large immigrant workforce is necessary to maintain productivity in the construction sector. But it is unavoidably accompanied by risks to safety and hence reduction to productivity due to the differences in the skills and cultures of the immigrant workers.

In Singapore, the common method of protecting the immigrant worker is to expect minimum understanding from him/her and over-protect him with extra PPE. This results in increased risk to the worker, and lowered productivity due to the extra PPE.

A productivity alternative would be to evaluate worker-dependent hazards in greater detail, and implement improved training, continuous supervision, and better communication.

A common example of possible mismatch between the intent of training and the worker's understanding of the issues is in the issue of the body harness for fall protection. Such a topic is so complicated that even supervisors and engineers may overlook the many implications of the use of the safety harness for working at height and the many concomitant requirements to be satisfied for its effective use, as highlighted by the author in his paper [Ref 5].

With the unique situation regarding the immigrant labour force in Singapore, it is critical to include the risk awareness of the worker into the productivity equation, and allow for predictable variations.

The immigrant worker is quite sincere, very hard working and fully loyal, if only because he/she has made many sacrifices to come over, leaving family behind, to work for a wage which the

local workers would not consider worthwhile, with the main object of saving from his/her earnings and sending it home to make a better life for dependents there.

But language and culture-based differences, and the threat of the permit-to-work being cancelled at any time, make the worker a nervous and timid individual, too afraid to express doubts in understanding and ask for clarifications, ending in ad-hoc and usually unsafe acts created by unsafe conditions.

That is why almost all the workplace accidents in the hazardous industries involve immigrant labour, and most of it traced to inadequate risk assessment and control. After exhaustive study, the author believes that continuous supervision of immigrant workers assigned to hazardous tasks would reduce accidents.

The author recommends asking questions during risk assessment, such as:

- Does the worker appreciate the need for the safety harness, and where and how it can reduce the force of fall impact?
- Does he understand the concept of 100% tie-off?

Replies to these and similar questions will highlight the need for special handling of hazardous tasks, automatically resulting in maintaining and even enhancing productivity.

New materials

New materials or novel uses of existing materials will invariably improve productivity, but may either reduce productivity due to unfamiliarity of the material and its usage characteristics, or sometimes introduce fresh risks which will, in course of time, affect productivity.

A risk analysis before introduction of the new materials will alert the management to anticipate and control deterioration of productivity at the beginning or after regular use.

Aluminium for instance, being lighter, considerably reduces manual handling and other ergonomic risks, but its storage and use need special care to avoid galvanic corrosion with steel. Also, its lightness itself, enabling longer and bigger pieces to be carried and handled, may result in injuries related to size, such as long rods hitting people and objects while turning. Similarly, use of a faster-setting or stronger cement may raise fresh problems of skin diseases.

Role of Management

While management may play an enabling but relatively passive role in risk management, its impact on productivity through risk management can be very high. The key factor here is that while in most advanced countries, safety is a worker-driven imperative, in Singapore it is management-driven, and to that extent, management has a special role to play in the reconciliation of risk management with productivity. In other words, it is management which normally focuses on productivity and other successful business practices that must also watch out for good risk assessment and management.

It is management's responsibility to ensure that RM must not be treated as a paper exercise, merely repeating past practice to satisfy codes and regulations, and that RM is reviewed

frequently, to determine if and how it affects productivity, findings are communicated particularly to the workers and other personnel who face the risks, and decisions are implemented promptly and fully.

In particular, the interaction of safety measures and productivity improvements must be specifically studied through risk assessment and special attention paid to the following:

- Prompt and full incident reporting
- Prompt and frequent risk assessment
- Adoption and monitoring of a hierarchy of controls, instead of just increasing PPE
- Provision of accessory requirements to safeguards, such as adequate numbers and capacities of anchors for safety harnesses and prompt and proper rescue measures for suspended fall and confined space victims
- Strict and continuous supervision for hazardous activities

Short cuts in the risk management process will hide fresh and worsening risks at the workplace, slowly and silently reducing productivity. Not providing continuous supervision where necessary will accumulate and worsen unnoticed risks.

Communication

“What’s the most important factor in implementing a world-class safety program for your organization? Communication. Without it, the most well thought out safety program will be nothing but a good idea” – thus states a recent article [Ref 6].

This quote is from a country where English is almost the sole spoken and written language. The US, for instance, found that the accident rate for immigrant labourers from Mexico was 70% higher than for native Americans, and the excess was discovered to be due to a lack of understanding of instructions.

Equally important was the fact that the immigrant (and even local) workers were not aware of company goals and targets. They were told only about daily work targets when, in fact, they would have liked to know the overall scope of site activities and project.

Singapore, already multi-lingual, has the added problem of immigration from many Asian nations with different languages and safety culture orientation. Because of the added language barriers, many managers simply give the worker a job, explain the minimum requirements, and let him fend for himself as best as he can – resulting in more risk and less productivity.

Management must ensure two-way communication on all safety matters between supervisors and workers, not only for explaining, but also in confirming that the intent and content of the explanations have been understood and accepted by the worker.

Apart from their role in arranging for the conduct of risk assessment and control implementation, enabling training, safe work procedures (SWP), production of safety brochures and posters, the communication of risks and their control to the work force has been proved to be a catalyst for productivity, with the worker becoming a partner rather than a hireling carrying out instructions. In regard to a safe work procedure, it

must not be forgotten that SWP is now a required control, but is also a natural follow-up of the hazard identification process.

A case in a point is the charge that many workers fall from height and die because they climb guard-rails. Investigating this charge would show that most of the time the worker did the unsafe act because he had been given no alternative procedure to reach the assigned task – which therefore shifts the act to an unsafe condition, instead of an unsafe act. This could have been avoided by identifying the need for safe procedures for handling the out-of-reach task, during risk assessment.

INTERACTION OF RISK CONTROLS WITH PRODUCTIVITY

Risk management required by the WSH Act, consists of hazard identification, risk assessment, and risk control. Productivity is affected at each stage. In particular, many risk controls may have adverse consequences. But careful analysis will show that most set-backs would be only temporary, and many can be turned around and converted to benefits.

The mandated hierarchy of risk controls in Singapore is: Elimination, Substitution, Engineering Controls, Administrative Controls, and PPE.

Elimination

In elimination, the item is removed from risk assessment and does not appear in the risk matrix any more, and hence generally there will be no effect on productivity. However, temporary adverse effects are possible.

If elimination is by change of product or process, productivity will be reduced by the following:

- Retraining and adjustment to new product or process
- Investment in new product or process
- Slow learning curve
- Increased supervision

If elimination is by sub-contracting to specialists, productivity may also be reduced (i) by the reliance on an external management with concomitant impact on internal project management, and (ii) by some reduction in profit.

But once ROI is achieved, and staff become familiar with the modified product or process, or collaboration with experts, productivity will recover with improved safety.

Substitution

Substitution of a product or process by another, less hazardous one, is generally not only safer, but also less stressful on the worker; due to the following reasons:

- Demanding less physical and mental stress in tasks
- Requiring less use of PPE
- More relaxed environment, offering more confidence to the workers, and improving their ability to focus on the job.

Thus, risk will be reduced, but productivity also may be reduced, at least temporarily. For instance, dividing heavy loads into lighter portions will involve a little more manpower and time.

By using water-based paints instead of solvent-based paints, there would be the need for more frequent repainting.

Reducing speed means that it would require more time to reach the destination or to finish a job. Safer processes may often be slower.

However, if properly managed, substitution can increase productivity in the long run, due to the improved safety culture, and fewer occupational health problems such as musculo-skeletal disorders (MSD) and lung diseases.

Always in the background is the real possibility that the productivity gains of a decade may be wiped out by a single accident or occupational trauma compensation.

Engineering controls

Most engineering controls increase productivity, directly and promptly, inspiring confidence in workplace safety and improving comfort at the workplace. Guard-rails, toe-boards etc are visible reminders of safety and physical barriers against hazards. Noise barriers remove a constant source of irritation.

Fire extinguishers, automatic sprinklers, machine guards etc are also visible markers of implementation of a safe zone of work. Ventilation systems, adequate lighting etc are immediate sources of physical well-being. Every ergonomic risk control measure will improve productivity to a considerable extent.

As engineering controls are passive safeguards demanding little from individual workers, they do not hinder productivity, and as was discussed under substitution control, may improve productivity due to increased confidence and comfort of the workers.

Administrative controls

To those who believe that administration implies only payment of salaries and other expenses, it may come as a surprise that as far as risk management is concerned, it is management that has to arrange for risk assessment and control recommendation, and, in addition, for permits to work, safe work procedures, training and certifications, brochures and posters, inspection, supervision and maintenance, and many other documentation and communication artefacts.

Obviously, the way all these are handled will have an effect on productivity, because they involve the human element which is the key to productivity.

Good safety communication, tool box meetings, awards etc promote productivity positively. A special point the author wishes to make is that supervisory personnel must be given the authority to carry out certain ad-hoc actions as the situation demands, such as the following:

- Stopping work when there is impending catastrophe
- Sending off a recalcitrant (or unsafe) worker
- Rotating tedious repetitive work with less onerous work between pairs of equally qualified workers.

Insufficient or inconsiderate communication, imposing stressful behaviour (as with disproportionate or public criticism), unsafe or uncomfortable working conditions, sloppy administrative practices such as no or poor SWP, careless risk assessment and control and implementation etc, will result in the following:

- Lower morale
- Reduce productivity
- Invite prosecution leading to stoppage of work, remedial measure slow-down, fines, decreasing profits etc

Thus it may be seen that administrative control can reduce productivity if mishandled, but if planned and executed correctly, it can be put to positive use as a productivity tool.

Personal Protective Equipment

Personal Protective Equipment (PPE) is known to be the least effective and hence hierarchically the last risk control. Regrettably, many in industry use PPE as the first option, because it is in many ways the easiest, fastest, and simplest option.

The reasons for it being the last risk control are well-known, including (apart from the expense being directly proportional to the number of workers) the need for a correct fit, individual training and extra supervision, and the potential for fresh dangers arising from the use of the PPE.

What is of most concern for the subject at hand is that PPE has the most adverse impact on productivity. Every single item of PPE adds some stress to workers, impeding his/her work and increasing his/her discomfort with continuous and long-time use, as the following examples will show:

- The helmet is not a hat protecting the worker from the hot sun over an eight-hour day, it actually heats up the head – the chin strap adds to the problem.
- Ear-plugs reduce noise-induced deafness – but it is also an irritant, and may increase the risk due to not hearing warnings of impending danger, or important instructions spoken by the supervisor.
- Gloves protect the hands – but they reduce the feel and may reduce productivity, at least until the workers get used to the gloves.
- Masks and respirators protect the lungs – but they make breathing an effort and a distraction from the job.

Most PPEs are necessary and required by regulations and good practice, and the loss in productivity must be accepted. But certain PPEs are used when uncalled for, and in such cases, the reduction in productivity is a direct result of avoidable PPEs.

One prime example of excessive, unnecessary use and misuse of PPE may be the safety harness.

As mentioned earlier, the safety harness is only a part of the fall protective system, to hold up the falling person at an acceleration that his body can tolerate, and prevent him from hitting the base. This requires, among other requirements, the following:

- Sufficient fall clearance (of at least about 5m)
- Easily accessible anchors of adequate capacity, to resist the impact force of a sudden fall arrest (15kN-16 kN)
- Prompt rescue after falling (within about 20 minutes), as more fully described in Ref 5.

This still does not address the intense personal discomfort which a properly worn 'snug tight' safety harness would impose on the long-term wearer, as against the loose and badly fitting harnesses currently worn.

Another productivity facet of safety harness use that is often overlooked is that the safety harness, being PPE, should (even legally) be the last choice for fall protection, after:

- Elimination of working at height
- Substitution with alternative collective methods of safe work at height such as MEWP
- Collective fall prevention engineering controls such as edge restraints and collective fall protection engineering controls such as safety nets and other soft landings
- Collective administrative controls such as better SWP, closer communication and continuous supervision
- Individual fall prevention PPEs such as travel restraints and work positioning, and only finally reaching the safety harness.

Each lower element in the hierarchy can potentially lead to worse impacts on productivity. Here again, risk management will help identify, assess, and control the risks and avoid wastage of resources and aggravation of risks due to overuse or misuse of PPEs.

CONCLUSION

It should be clear from the foregoing that in most cases, risk management, conducted in the way suggested, should promote productivity rather than reduce it.

What everybody would like is that each safety improvement activity we take should not only raise our safety level but also increase our productivity, as in line (a) of Figure 4.

The reality however is that, in most cases, a safety intervention will lower productivity as an immediate consequence, but continue at the previous rate. Sooner or later, it may tend to catch up with the original productivity level, as at 'x' in Figure 4. Overall, there would be some temporary productivity loss, as in line (b) of Figure 4.

However, with risk assessment and pre-planning the initial drop could soon be overcome and productivity can also show improvement, as hoped for, by line (c) of Figure 4.

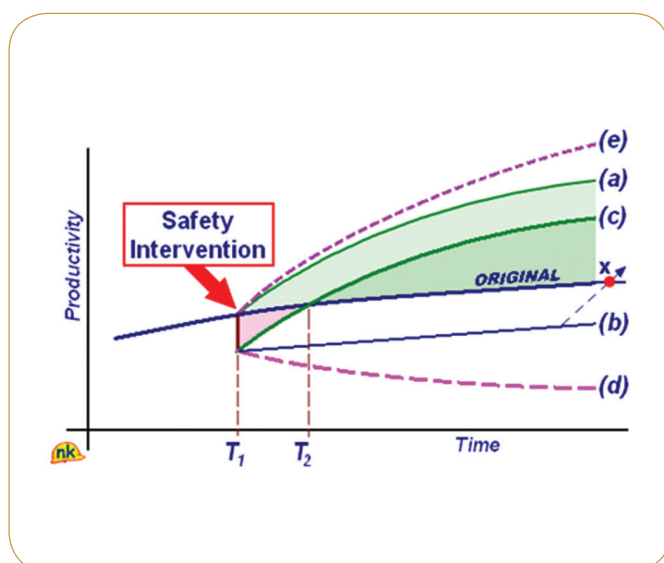


Figure 4: Impact of safety interventions on productivity

If management has a negative attitude and things do not work out, a safety intervention may lead to deterioration of the status quo, as in line (d) of Figure 4.

Conversely, with proactive planning and tight control, not only the drop may be eliminated, but also the additional benefits of improved safety may begin to show up soon and productivity may actually improve beyond the original rate, as has been shown in many case studies [Ref 7], as in line (e) of Figure 4.

For too long have safety personnel and productivity officials toiled in separate worlds. It is time that management, with the coordination and collaboration of all stakeholders, facilitated the two departments to act within a common framework, reinforcing each other's aims and balancing each other's difficulties.

(Major segments of the article are based on a slide presentation made by the author titled: 'Risk Management Promotes Productivity' at the IES Seminar on 'Safety Drives Productivity', which was held on 31 October 2011. More information on the author and his work can be obtained from www.profkrishna.com).

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