

# Applying TQM Principles in Safety Management A Study on the Effectiveness of Total Safety Management

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## Abstract

*In the light of Total Quality Management (TQM) principles, some safety management theorists have drawn an analogy and put forward different Total Safety Management (TSM) models in hope of achieving a major leap-forward in safety management. However, sharing the same drawbacks of TQM, the theoretical base of Total Safety Management (TSM) has not been adequately explained. Moreover, the effectiveness of TSM in improving safety performance is largely unexplored. This article re-interprets TQM principles in safety management terms and investigates the correlation between TSM principles and safety performance through conducting a survey in Hong Kong construction industry. Survey results indicate that some of the proposed TSM principles have a positive association with safety performance.*

**Keywords:** Safety, TQM, Total Safety Management, construction, Performance.

## 1. Introduction

### 1.1 The significance of TQM on performance

TQM is widely perceived as a performance enhancing program. As reported by Reger and et al (1994), hundreds of anecdotal cases of TQM show that a properly implemented TQM program will improve organizational performance. According to Sila and Ebrahimpour (2005), the positive effect of TQM is attributable to two underlying factors namely 'leadership' and 'information and analyses'. They propose that 'the importance of TQM factors may be contingent upon such factors as the industry environment, firm size, and country of origin of companies' (Sila and Ebrahimpour 2005:1144). Under the same rationale, if TQM principles are to be adopted for application in safety management, the principles should be reinterpreted in the context of safety management.

### 1.2 Adaptation of TQM to Safety Management

The similarity between quality management and safety management has been well articulated by researchers (Karuppan et al 1996, Loushine et al 2007). In the light of TQM principles, safety management theorists and practitioners have put forward a variety of Total Safety Management (TSM) models and bestow managers with a new approach to safety management. For examples, Karuppan (1996) claims that the TSM approach will excel the traditional compliance based safety management system, Geller (2001) postulates that in a total safety culture, safety is a value rather than a priority; he further proposes ten principles for refining safety attitudes and behaviors.

Weinstein (1998) points out the relationship between behavior-based safety and total quality management and the ways in which TQM principles can be used to improve the effectiveness of behavior-based safety programs. While most TSM theorists have drawn a parallel analogy between TQM and TSM, not much work has been done in regard of the practical meaning of TSM and its effectiveness in improving safety performance. In the circumstances, the plea of Hackman and Wageman (1995) on TQM is equally if not more right for TSM - if TQM is to gain parity in the academic community, theorists should go back to the fundamentals of TQM and focus their attention on the mechanism through which TQM practices realize their effects.

## **2. Total Safety Management Principles**

### **2.1 From TQM to TSM**

Though the similarity between safety management and quality management is well explained (Karuppan et al 1996, Loushine et al 2007), one must be fully aware of the contextual difference between Quality and Safety. Quality is for meeting client's requirements and is expected to have direct revenue. However, the client of safety is the general staff members and workers; revenue is largely unmeasurable, and effectiveness is only faintly discernible through accident statistics. Therefore, the re-interpretation TQM principles in safety terms must be done radically down to the original fourteen principles of its proposer (Deming 1986).

### **2.2 Create constancy of purpose toward improvement of product and service**

Deming (1986) has proposed two purposes that constancy is needed - first, the purpose of today in maintaining quality standard and becoming more efficient, second, the purpose of tomorrow in coping with external changes for long-term survival.

For the first purpose, constancy is by itself a cultural characteristic that drives a policy of long time horizon and highly risk-avoiding (Hofstede 1980) through continual refinement to processes, that is quality assurance. The second purpose of coping with tomorrow is a strategy of being customer oriented. Again this purpose can be perceived as a culture of change and adaptation to the environment through which company performance can be better assured (Kotter and Heskett, 1993). Therefore, in TSM, there shall be:

- A safety policy featured with high risk-avoidance and long term reliability over short term success; and
- A strategy of adapting to external changes such as new safety regulations, new technologies, and social expectations on safety.

As the foundation of safety policy is the safety culture of a company, this constancy culture and adaptive strategy shall be adopted as the normative culture of the company and reflected through its safety policy. According to Uttal's (1983), safety culture is defined as the shared values (what is important) and beliefs (how things work) that interact with an organization's structures and control systems to produce behavioral norms (the way we do things around here). With this constancy culture in mind, what shall be done to achieve this cultural change? Reason (1998: 294) opines that thinking and believing can be shaped by organizational control through acting and doing. If TSM is taken as a kind of safety culture, then the TSM principles discussed below form the contents of this specific TSM culture.

### **2.3 Adopt the new philosophy**

The new philosophy proclaimed by Deming consists of lapses that are readily found in organizations: commonly accepted defect level, people whom do not know what their job is, inadequate and ineffective supervision, management not rooted in the company, Job hopping, and vandalism. These lapses are even more obvious in safety: company that accepts a high accident rate, people that do not know what their safety duties are, inadequate and ineffective safety supervision, management not believing in the importance of safety, safety as other people's job, and vandalism of safety measures. These accusations are strictly in line with Reason's (1998) ideas on the problems of having a poor safety culture - an inability to appreciate the full extent of the operational dangers and an unwillingness to deal proactively with known deficiencies in safety. What Deming is promoting is a fundamental change in our belief system – that is a double loop learning (Argyris and Schon 1978) in safety (Nielsen, 2014), a philosophy of challenging what are being tolerated as acceptable. In short, TSM shall be a pursuit of:

- A safety culture that drives the policy of rejecting long tolerated lapses - i.e. high in risk avoidance, and
- A double loop learning process in safety through leadership at all levels to change the basic assumption of general staff members – accident is preventable and safety is the essence of business success.

In this sense, a company advocating TSM must take actions to reshape the belief system (thinking and believing) at all levels by organizational control through acting and doing. (Reason 1998: 294).

### **2.4 Cease dependence on mass inspection to achieve quality**

The key words of this TQM principle are 'dependence' and 'masses'. 'Cease Dependence' implies that 'Inspection' is not the end of quality management; one should not rely solely on mass inspection to resolve all quality problems simply because it is too late to prevent defects from happening.

Yet Deming does not rule out the necessity of conducting inspection; he is opposing mass inspection but not inspection. This approach is discernible from his emphasis on statistical process control that can only be achieved through inspection.

In TSM, the same rationale applies; if all processes are conducted safely, then high frequency of safety inspections is unnecessary. Therefore, only sporadic safety inspections are required to collect data for further analysis and driving continual improvement. In essence, inspection becomes a preventive measure instead of being a corrective action. This practice is strictly in line with the requirement of contemporary safety auditing schemes in which safety inspection finding analysis is always a mandatory requirement. The results of this analysis are taken as the input for correcting system errors and driving continual improvement. In this connection, safety inspection shall be:

- An effective safety control and continual improvement program that can identify underlying root causes e.g. lack of safety training, not the symptoms of bad safety management.

This new approach also concurs with contemporary studies on safety performance which rebut the use of lagging indicators such as accident rate (Agwu 2012, Podgorski 2015). Instead, many scholars advocate the use of leading indicators such as worker engagement levels for predicting safety performance (Wachter and Yorio 2014). Therefore, a TSM programme shall promote proactive participation instead of enforcing reactive compliance.

### **2.5 End the practice of awarding business on the basis of price tag alone**

This TQM principle is a controversial business strategy. It is in conflict with the resource dependence theory which articulates that inter-organizational relationship is competitive as opposed to cooperative (Dean and Evans 1994). Yet Deming is urging for a collaborative and non-competitive relationship with suppliers. This principle, when considered together with the preceding principle of inspection, sounds rational. If incoming materials are not subject to mass inspection, then quality could only be assured through employing reliable suppliers. Therefore, a long-term collaborative relationship is essential for assuring material reliability. Another consideration of Deming is total cost instead of price tag. Total cost, as articulated by Deming (1986), includes the cost of rejects, subsequent corrections, and the administration cost spent on sourcing and switching suppliers. This rationale is equally right in safety - if a service provider with poor safety capability is engaged, extra cost will be incurred in terms of increased insurance cost, delays caused by accidents, and other expenses incurred in compensation and legal proceedings. Therefore, in TSM, company shall adopt a business strategy of:

- Considering the safety capability of prospective suppliers (sub-contractors), and
- Using suppliers (sub-contractors) with good safety capability.

Again, this practice is in line with the requirements of contemporary safety management programs such as the OHSAS18001 – supplier prequalification, selection and control are management mandates.

### **2.6 Improve constantly and forever every process for planning, production, and service**

This ever-ending effort, as Deming claimed, must start from the design stage that includes both the product and production processes. Once a process is commenced, it will be too late to prevent producing sub-standard products. In a recent study on safety culture (Hasse et al, 2015), the interaction between Human, Technology, and Organization is well explained and the need to review the whole of a system for improving performance is highlighted. Similarly, as pointed out by Reason (1998), a poor process design might result in “Necessary Violations” – violations that cannot be avoided just because of the inherent inadequacies of the equipment to be used or workplace planning.

Another key emphasis of this principle is “constantly and forever”; it is thus in-line with the Japanese approaches of Kaizen and quality circle; improvements are achieved gradually and at all levels. Such an improvement program could only be effective when an efficient and fair communication system is in place (Reason 1998). In this sense, this TQM principle adopts a systemic perspective covering all levels and functions of a company.

Under the same rationale, safety must be built in at design stage to reduce risk content of processes; continual improvement to processes must be maintained and fueled with good leadership. An ethos proposed by Deming is that ‘Today is better than yesterday’ (Deming, 1986:50). Therefore, in TSM, production processes shall be characterized with:

- A pervasive risk avoiding culture adopted by all functions,
- A leadership style that drives daily improvement to all processes at all levels, and
- An effective communication that enables the free communication of improvement ideas.

These three contextual attributes, namely a risk avoiding culture, proactive leadership, and effective communication, circumscribe the entire TSM philosophy and at the same time assure a better control on all production processes.

### **2.7 Institute training on the job**

It is a subtle irony that Deming is urging for a ‘totally reconstructed’ training program that begins with the management as if they were incompetent. In the example quoted by Deming (1986), a foreman is regarded as knowing nothing about the job that workers are doing. When this principle is applied to safety, the situation is even worse than that of quality – supervisors do not know the safety procedures for processes that they supervise; safety measures are skipped just because supervisors do not appreciate their implementations. In this sense, frontline staff must be re-trained on safety rules and methods.

As for management staff, especially in organizations where production and commercial goals are valued higher than those relating to safety (Hasse et al 2015), they shall be re-educated as well as re-trained on safety so as to change their mindset on the importance of safety. Particular emphasis shall be placed on the four in one nature of the four basic performance attributes namely safety, quality, progress, and cost (Li and Jones 2010).

Therefore, under TSM principles, there should be a totally reconstructed safety-training program that trains

- The management on the meaning of safety culture, the importance of safety to business, and the safety requirements of various production processes, and
- Supervisors and workers on the safe way of executing works.

### **2.8 Adopt and institute leadership**

It is obvious that most studies on TQM point to the importance of Leadership (Mallur et al 2008, Ola 2013). If we look back to the “Baldrige Model” of 1990s, leadership takes the center stage and marks the start point of the model. And in the same vein, Deming’s ‘institute leadership principle’ implies the indispensability of leadership for driving the entire TQM system. According to Deming (1986), leadership is not simple counting; it is instituted to replace the Western style of focus on outcome – management by objective, management by number, Quota and Target. Without the constrain of targets, good performance can be achieved through leadership. Therefore, leadership must be operationalized (Geller, 1994, 2000). Leaders must know the work they supervise and how can it be done safely. They must be empowered and directed to inform the senior management. In this sense, leadership resides in all functions and at all levels; leadership is thus better described as the mode of interaction mediating the entire management system (li and Jones 2010). Therefore, under TSM principles, the safety management system is characterized with:

- A proactive safety leadership streaming down from the top management to the frontline staff and integrating all functions together in pursuit of safety goals, and
- A leadership style that strives for the realization of the TSM safety policy instead of meeting numerical targets; they, managers and supervisors, should focus on winning over the minds and hearts of workers (Wachter and Yorio 2014).

### **2.9 Drive out fear**

Deming claims that ‘no one can put in his best performance unless he feels secure’ (1986:59). This ‘drive out fear’ proposition is equally right in safety. In a study on accident prevention, Wachter and Yorio found that safety performance associates indirectly with worker engagement levels (Wachter and Yorio 2014). They also pointed out the need for winning over the minds and hearts of workers through human performance-based safety management systems.

And as discussed above, it is necessary to collect accidents, incidents, and near misses information for analysis. Yet it is difficult to convince employees to confess their own lapses and mistakes and report near misses of others as observed. To overcome this dilemma, the management needs to establish a “reporting Culture” and a “just culture” (O’Leary and Chappell 1997) that enable and encourage employees to provide the earnestly needed safety data. This approach is perfectly in line with Deming’s principle of “Drive Out Of Fear”.

Perhaps the most commonly seen fear is the fear in failing a production target leading to the practice of shortcuts that compromises safety procedure. In a study on safety culture and risk taking behavior, safety performance was “perceived to rest on the individual, whereas the work environment and priority of productivity constitute constant obstacles” (Hasse et al, 2015:131). So it is absolutely unfair to workers if they are held fully responsible for causing unsafe incident. If workers are not fear of breaking administrative rules or failing a production target for the sake of protecting safety, accident could be prevented. In fact, workers’ right to voice out their safety concerns is protected by law in Hong Kong under the Factory and Industrial Undertaking (Safety Management) regulation. Therefore, with this principle in mind, a TSM programme shall feature with:

- Safety as value (Petersen, 1994; Geller, 1994, 2001) –one that is to be protected among other situational priorities;
- A reporting culture and a just culture that encourage employees to report near misses and incidents,
- A personnel policy that encourage peoples at all levels to participate in protecting and advancing safety; and
- A positive leadership style that founds on coaching and helping (Geller, 1994, 2001) but not on fear.

### **2.10 Break down barriers between staff areas**

This principle appears to be trivial and has not been accounted for by early TSM theorists. Besides the physical meaning of barriers, Deming’s account on this principle points to the systemic nature of organization and urges for collaboration among different departments in problem solving (Deming, 1986: 63). From a cultural point of view, the breaking down of physical barriers bears a symbolic meaning (Pondy et al, 1983; Jones, 1996) of collaboration and free communication.

In safety management, the breaking down of [communication] barriers is much needed under the “Reporting Culture” that is needed for collection of incident and near miss data (O’Leary and Chappell 1997). In companies with a less than appropriate safety culture, safety is regarded as the duties of safety personnel and the safety department; ideas and requests from safety personnel are not respected and ignored. In this sense, this breaking the barrier principle adds back the much required esteem and influence of safety personnel for achieving its functional goals. Again, the realization of a barrier free environment relies very much on the proactive leadership of the top management. Therefore, under TSM principles, an effective safety management system shall have:

- An effective safety coordination and communication process through which safety ideas and instructions are freely and effectively communicated,
- Safety needs are adequately considered in decision making processes, and
- Management decisions are suitably balanced with adequate concerns on safety.

### **2.11 Eliminate slogans, exhortations, and targets for the work force**

A Poster may be meaningless, reminds workers of management’s ignorance, and turns them cynical. Yet the focus of Deming is not the use of posters but what the posters say. Deming has raised a simple example in which workers are urged to ‘do it right first time’. But how can it be achieved if the incoming materials are off-gauged? A poster like this will certainly turn workers off for they are deemed to fail the unrealistic target of ‘do it right first time’. Similarly, it is widely heard that the top management is striving for ‘Zero Harm’. So could it be achieved under the prevailing culture and physical condition? If not, then the exhortation becomes the source of cynical responses. Conversely, in a study on the effect of political skill on safety climate, apparent sincerity is a factor that influences the success of safety management tasks implementation (Sunindijo et al 2012). Therefore, Deming articulated that managers must manage with action, not lip service and the use positive symbols and signals to boost morale. In TSM, there should be in place:

- A culture and leadership style of management by facts and high sincerity, not by empty exhortation and fear; and
- An operational practice of using positive symbols and signals to boost safety morale.

### **2.12 Eliminate numerical quotas for the work force and goals for management**

Deming regards quota as a fortress against improvement of quality and productivity in the sense that no quota is appropriate with never-ending improvement (Deming 1986:71). One may argues that a quota that is commensurate with the current environment may induce better performance or higher output.

However, as points out by Deming, different workers have different ability; those can produce more will tend to slow down when the target is near while those are incapable will rush their jobs and produce substandard products. Therefore, quota will cause more harms than benefits and this situation is even more ironic in safety. Consider the following examples:

Example 1: We (a construction company) have 1 less fatal accident this year; we are working well!

Example 2: Don't reduce the target accident rate too much; we want a bigger improvement figure!

Example 3: Why bother; the current accident rate is by far below the target!

In example 1, the company is celebrating someone is killed; in examples 2 and 3, improvement is restricted. Literally, both a notional safety target and a zero accident target should be rejected. The targets that can be adopted, according to this principle, are those positive and achievable operational targets such as a more comprehensive maintenance program for plants, and an enhanced training program for employees. Therefore, under TSM principles, a safety management system should:

- Be free of unrealistic numerical targets,
- Be managed by facts and effective leadership (principle 7 above), and
- Be driven by positive and constructive signals (principle 10 above).

Conversely, the management should use numbers to surface the root problem. A high accident rate should not be construed simply as a failure to meet the target. It is an indication of a management problem to be further explored.

### **2.13 Remove barriers that rob people of pride of workmanship**

Deming regards the annual rating or merit system is the barrier that robs people of pride of workmanship and therefore should not be practiced. There are two underlying reasons for doing without a rating system - first a belief in intrinsic motivation (Anderson et al 1994; Waldman, 1994) and second, a belief in system constrains (Waldman 1994). On one hand, Deming (1993: 124) advocates the power of intrinsic motivation such as dignity, cooperation, curiosity, and the innate capability of learning; therefore, he urges to remove extrinsic rewards. On the other hand, Deming has stressed repeatedly that performance does not depend solely on individual capability, but on system constraints such as characteristics of technological and work processes, organizational policies, structure, and culture. Moreover, Deming regards performance rating as subjective in nature and unfair in adverse situation.

In safety management, it is common to find safety items in performance rating systems and inter projects or departments safety competition. They do have a symbolic effect in nurturing a positive safety culture. Yet if they are conducted in an unfair way, then their adverse effects might exceed their possible benefits. Much in the same vein, positive reinforcement, as articulated in the Behavior Based Safety Guide (Health and Safety Authority, Dublin 2013), results in employees taking personal account for safety. The need of protecting 'pride' is thus highlighted once again. Therefore, in the operational domain of TSM, It will be more desirable to have:

- Non-performance based safety competition for the promotion of safety culture, and
- Positive reinforcing safety motivation rather than negative penalizing safety control mechanism.

### **2.14 Institute a vigorous program of education and self-improvement for everyone**

Deming claims that there is no shortage of good people, but a shortage of high-level knowledge. (1986: 86). In this principle, Deming is stressing two points – first, everyone should pursue self-improvement, and second, knowledge is the root of competition. Both points are tightly in line with the concept of learning organization—an organization that is continually expanding its capacity to create its future (Senge, 1990:14). Organizations learn only through individuals who learn (Senge, 1990:139). Similarly, Deming brings learning down to individual level; when everyone is learning, the company will expand its knowledge base and benefits from it. And according to Senge (1990), the only frontier that companies compete is by learning faster than their competitors. In this sense, learning is taken as a strategy for continual success. This idea is analogous to Deming's idea of customer satisfaction – one must learn from customers before their needs can be satisfied. Therefore, Deming's TQM principles, at least some of them, are describing a learning organization. As for the question of what should be learnt, Deming (1990) has articulated two types of knowledge – first, process task knowledge, and second, profound knowledge. The former refers to science and technology; the second refers to management knowledge such as statistics and systems theory. Therefore, in TSM, there should be:

- A comprehensive safety training program on both job related safety and safety management theories; and
- A leadership style that create a learning climate in constructing a learning organization.

### **2.15 Take action to accomplish the transformation**

A logical question to this principle is ‘what is to be transformed?’ From the foregoing thirteen points, Deming’s focus on leadership, training, and continual improvement appears to be heading for a fundamental change in the value system of organizational players at different level – seniors shall adopt constancy in purpose and focus on the context rather on targets whereas workers should be emancipated from the fear of meeting targets and should even take pride in their works. All of these changes are the manifestations of a fundamental change to beliefs and value system of organization.

In safety management, safety is usually taken at a lower priority and frequently played down by production ends. If safety is to be assured, then Deming’s urge for ‘transformation’ is even more critical and needed than quality concerns because quality is always a part of the product whereas safety is not. In this sense, double loop learning, a basic query on why instead of a superficial learning on how to do becomes the only mean to accomplish this transformation.

On the ‘Take Action’ part of this principle, Deming’s systems and process view on organizational activities is once again highlighted - every job is a part of a process, a process consists of stages, and each stage works with the preceding and the next stage toward optimum accommodation (Deming, 1986:87). To this end, the Plan, Do, Check, Act (PDCA) cycle is offered as a generic tool for continual improvement. The PDCA cycle is applicable in both daily operational planning and overall planning at project or corporate level. The idea of linked stages bears critical meaning in some industry such as the construction industry. It is critical for safety for the preceding operation to be considerate of the subsequent trade. One may goes away with an unsecured guardrail or platform leading to an accident to workers of the following operation. Therefore, the actions that should be taken to accomplish transformation include actions in education and the promotion of a safety culture that revert unsafe behaviors to safe practices. Under TSM principles, there should be:

- A detailed plan for accomplishing safety culture transformation (Goetsch, 1998) through double loop learning; and
- A positive transformational leadership that encourage workers to revert unsafe behaviors to safe practices.

### **2.16 Sectional Conclusion**

To sum up this discussion, the adaptation of TQM principles for safety management is both a sensible and practical approach. Similar to TQM, TSM takes effect basing on leadership, double learning, and safety culture transformation. In order to visualize the effectiveness of TSM principles in improving safety performance, a survey on TSM effectiveness has been conducted.

## **3. The effectiveness of TSM on safety performance**

### **3.1 The Survey on TSM implementation and safety performance**

With the re-interpreted safety meanings of TQM principles, a questionnaire survey is conducted to gauge the extent of TSM implementation and safety performance of Hong Kong construction companies. The data collected are analysed by using the regression method with the extent of implementation of various TSM principles as independent variables and safety performance as dependent variable. Analysis results show that safety performance associates strongly with the extent of implementation of some TSM principles. With these findings, safety managers and construction practitioners are inspired of the TSM method to improve the safety performance of their companies.

The questionnaire used has a bi-polar strength design that guides the respondent to return a rating between two extremes of full implementation (+3) and null implementation (-3) of TSM practices that represent the fourteen TSM principles. There are 28 questions on TSM practices – two for each of the fourteen TSM principles. Another five questions are used to gauge the safety performance of responding companies. Table 1 below depicts the questions on TSM practices used in the survey. The questionnaire was sent to both project and safety management staff at different levels of selected construction companies in Hong Kong. Altogether one hundred and twenty completed replies have been obtained. They were initially screened for obvious mistakes and acquiescent responses and only ninety nine replies have been accepted for data analysis.

**Table 1: The First Two Question of the Survey Form.**

(+3)Positive Side	Negative Side (-3)
Our safety culture is high in risk-avoidance; we always take proactive action to rule out potential safety hazards.	Our safety culture is low in risk-avoidance, we are always reactive to imminent safety needs.
We always internalize external changes such as new safety regulations and technologies and best practices in the least possible time	We are always reactive to new safety requirements and take action only when something bad has happened.
We do not tolerate a high accident rate and will take drastic action to restore it under control.	Accident rate is not our concern, nobody bother whether it is high or low.
Our people at all level understand and take seriously the safety duties assigned to them and will take action to discharge their safety duties.	Our people do not take their safety duties seriously or regard safety actions as the duties of the safety guys.
Our safety control system does not rely solely on very frequent safety inspection; other safety activities are also being carried out.	In our company, very few safety actions other than routine safety inspection are being carried.
Our safety inspection program aims at identifying the underlying safety problems and driving continual improvement	Corrective actions OR no action will be taken in accordance with inspection findings and that is all of what we are doing for safety.
Safety performance is a prime concern in awarding tender to subcontractor.	Safety performance is not considered at all in awarding tender to subcontractor.
We will assess the safety performance of subcontractors regularly and action will be taken against poor safety performers.	We will not assess the safety performance of subcontractors; we take no action against poor safety performers.
We proactively invite safety improvement ideas from all levels and apply the ideas to improve our safety management system.	We do not provide a channel, both formal and informal, for workers to propose their safety improvement ideas.
Our safety procedures assure effective and continual improvement to all processes.	We only act reactively to suit our safety management system to imminent requirements.
It is mandatory for our management staff to attend a training course on the safety requirements of various production processes.	We do not require our management staff to attend any formal safety training course.
It is mandatory for all workers to attend a training course on the safety requirements of the works they are required to execute.	We have made no arrangement for workers to attend a training course on the safety requirements of the works they are required to execute.
We require staff at all level to understand how the works being managed can be done safely.	Most supervisory staff do not understand and will not care about how the works being managed can be done safely.
Our company requires all supervisory staff to lead their subordinates in perfecting safety measures.	Our norm is that safety is not the duty of work supervisors.
Our staff will certainly and fearlessly stop any work that is being carried out in an unsafe manner.	Our staff will not stop any unsafe work because stopping work for safety reason will be condemned by seniors.
We adopt a positive leadership style that founds on coaching and help instead of fear.	Seniors do not encourage perfecting safety measures, yet staff found responsible for safety lapses will be penalized.
There are both formal and informal channels for communicating safety information.	Safety information is rarely communicated among various parties and functions.
We are aware that safety is the duty of all staff members; safety is discussed openly among different functions and levels.	We regard safety as the duties of the safety personnel / department; other staff members rarely care about safety.
We only use practical goals and factual records for promoting safety performance.	We always use far fetching targets and impractical exhortation in promoting safety.
We use a lot of safety slogans and targets in safety promotion; our Company has a formally promulgated safety core value.	We rarely use safety slogans and targets in safety promotion; we do not have a safety core value other than the empty exhortation of "Safety First".
We have a safety target, yet it is only provided as a direction; our staff will perfect safety measures irrespective of whether the target is exceeded or not.	In our Company, safety target is a rigid mandate that cannot be failed; our degree of vigilance relates to our status in meeting the target.
Our Company has established safety goals, such as provision of safety training and equipment, and act accordingly to realize them.	Our Company has not established any safety goals to improve safety performance.
We have implemented a High Profile safety performance award program to promote positive safety behavior.	We have not implemented any safety performance award program for promoting safety behavior.
Our frontline staff always encourage workers to act safely and appreciate their safety awareness.	Safety awareness is never talked about and means nothing here.
We have adopted a transformative leadership approach to lead and educate workers and encourage them to improve their safe working behavior.	We do not care about workers' behavior improvement
We have adopted a transformative leadership approach to lead and educate staff members to enhancing their safety competence.	We do not care about the safety competence of our staff members.
Our Top Management always acts proactively to improve the safety culture and safety management system of our company.	Our Top Management places no concerns on the safety culture and safety management system of our company.
Our middle and frontline Management staff always acts proactively to implement the requirements of our safety management system.	Our middle and frontline Management staff always acts reactively and reluctantly to implement safety management requirements.

### 3.2 Data analysis and findings

Data analysis started with a correlation test between each independent variable and performance. In order to make statistical analysis easier, all data are shifted to the positive side by adding 3 points.



All together five TSM practices with a correlation coefficient of bigger than 0.45 and a significance of better than 0.05 have been identified. Table 2 below sets out the descriptions of these five TSM practices and their corresponding correlation coefficients with performance.

**Table 2: TSM Practices having a close association with safety performance**

Abb.	TSM Practice	Correlation Coef.	Significant Lev.
CCP1	Our safety culture is high in risk-avoidance; we always take proactive action to rule out potential safety hazards.	0.4611	1.22182E-06
CDI1	Our safety control system does not rely solely on very frequent safety inspection; other safety activities are also being carried out.	0.5205	2.41613E-08
CDI2	Our safety inspection program aims at identifying the underlying safety problems and driving continual improvement	0.4552	1.72751E-06
RBP1	We have implemented a High Profile safety performance award program to promote positive safety behavior.	0.4605	1.26375E-06
IES1	We have adopted a transformative leadership approach to lead and educate workers and encourage them to improve their safe working behavior.	0.5488	2.81519E-09

Each of these performance loaded TSM practices were then put through a least squares linear regression modelling with the performance index as the dependent variable. The regression modelling results indicate that all of the five independent variables show a significant level of better than 0.05 and the average standardized coefficient is around 0.5. Depicted in Table 3 below are the results of regression modelling. It is concluded that they are predictors of safety performance.

**Table 3: Results of regression modelling**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2.148	.336		6.395	.000	1.482	2.814
	CCP1	.398	.077	.461	5.170	.000	.245	.551
1	(Constant)	2.086	.298		7.001	.000	1.495	2.678
	CDI1	.421	.069	.520	6.065	.000	.283	.559
1	(Constant)	1.860	.396		4.693	.000	1.074	2.647
	CDI2	.444	.087	.455	5.087	.000	.271	.617
1	(Constant)	2.182	.330		6.611	.000	1.527	2.836
	RBP1	.408	.079	.460	5.162	.000	.251	.565
1	(Constant)	1.496	.366		4.090	.000	.770	2.222
	IES1	.553	.085	.549	6.532	.000	.385	.722

#### 4. Discussion

From Table 2, CCP1 refers to a high risk avoiding culture that corresponds to “constancy of purpose” in TSM. Culture is essentially a long term and prevailing common behavior that cannot be changed instantly; risk avoidance always implies a preference for safety.

Literally, constancy of purpose, in safety terms, refers directly to a strong safety culture; and as inferred by the strong association between CCP1 and performance, the stronger the safety culture is, the better the safety performance will be.

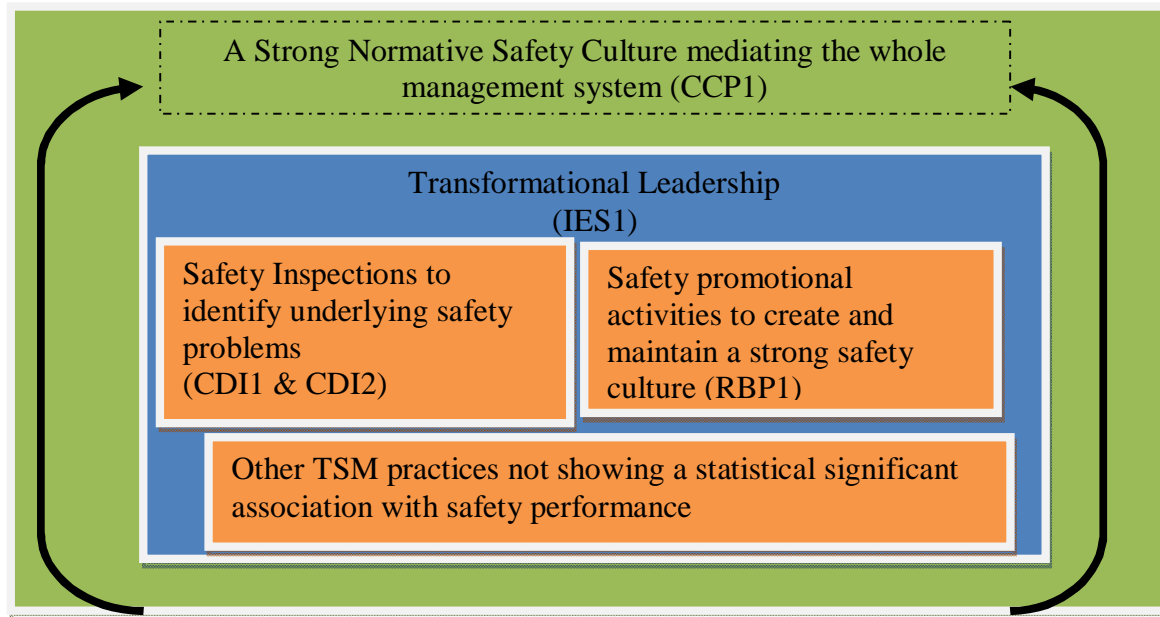
CDI1 means “Our safety control system does not rely solely on very frequent safety inspection; other safety activities are also being carried out.” This finding relates directly with the TQM principle of “Cease dependence on mass inspection to achieve quality.” A low score in this aspect implies that the company relies on safety inspection as the core practice of its safety management system. In safety, it is always too late to tell what has gone wrong – an accident might have occurred. Moreover, workers always tend to be reactive and give acquiescent response to safety inspectors; once the inspector turns around; the worker will revert to his quick and unsafe practice. So what should be done other than safety inspection?

CDI2 refers to the purpose of safety inspection – to identify underlying safety problems and drive continual improvement. The key point here is that safety inspection serves the purpose of continual improvement, not simply momentary correction, and blame allocation. This finding corresponds perfectly with the TSM principle of “Improve constantly and forever every process for planning, production, and service.” Yet the goal of “Improve Constantly” could never be achieved without the “Constancy of Purpose” in setting a strong safety culture. Logically, if the underlying cause of safety hazards can be effectively identified and then mitigated, safety performance will be improved.

RBP1 refers to the implementation of a “High Profile safety performance award program” to promote positive safety behavior. This management practice falls under the tenet of organizational culture as a form of “Ritual”. In fact, many safety performance awards and safety promotional contests are conducted regularly in both the public and private sectors of Hong Kong construction industry. This finding further confirms the effectiveness of safety promotional rituals in advancing safety performance. Conversely, company with no high profile safety promotional ritual reflects a weaker attention on safety from the top management. This will in turn leads to a weaker safety leadership that is needed for creating and thus maintaining a strong safety culture. Therefore, safety performance will suffer.

Lastly but not the least, IES1 refers to “a transformative leadership” for improving workers’ safety behavior. And needless to say, the safety behavior of workers constitutes the safety culture in workplace. In Hong Kong, workers are usually employed by subcontractors; they will inevitably carry their own safety cultures to common workplaces. It is the task of the Main Contractor to defend its own safety culture amid the various imported conflicting cultures of subcontractors. Therefore, the transformative leadership of the Main Contractor is essential to overcome the conflicting subcultures of subcontractors – the stronger this proactive leadership is, the better safety performance will be. To the contrary, if the leadership of the Main Contractor is weak, then the good safety culture of the Main Contractor, if it does exist, will be contaminated by the invading subcultures and safety performance will be impaired.

With the discussion on the five performance-loaded variables and the rationale that founds their effectiveness, a TSM VS Performance model emerges and is depicted in Figure 1 below.

**Figure 1: TSM VS Safety Performance**

With safety inspection and promotion as strong safety performance predictors, the whole TSM system is enabled through a Strong Normative TSM Culture and transformational leadership. The improving safety performance then adds as a positive feedback to the TSM system and further strengthens the TSM practices in place forming a virtuous cycle; this virtuous cycle then drives the continual improvement of the system that realizes continual improvement in safety performance.

### 5. Conclusion

While TQM is widely adopted for quality improvement, the study on TSM remains inadequate and deserves more attention. With the re-interpretation on each TQM principles, it is noted that TSM depends on proactive leadership and training at all levels to realize its effect.

The result of this TSM survey, though only five performance loaded independent variables are identified, does come up with solid recommendations for advancing safety performance. The finding points to the importance of having a strong safety culture and transformative leadership that enhances safety performance. Conversely, safety performance itself is a cultural element in the sense that the prevailing performance standard forms a guideline for safety management actions. Therefore, depending on the content of safety culture, either safety culture and safety performance will fuel a virtuous or vicious cycle until an effective intervention is introduced. That is to say the better and stronger the safety culture is, the better safety performance will be; and with the enhanced safety performance, the safety culture will be refined further and glow stronger. Under this rationale, managers shall take action to initiate this virtuous cycle that will improve safety performance continually. To this end, the actions described in Figure 1 (TSM VS Safety Performance) are inspiring.

Except for the five variables discussed above, the remaining independent variables fail to show a strong association with safety performance. Yet these variables and thus the corresponding findings should not be construed as having no effect on safety. This inconclusive result might be attributable to the fact that these safety management practices are less common and thus not widely implemented in Hong Kong. And by common sense, these failed variables are safety contributors; their effect on safety thus needs to be further studied and theorized. In this sense, further study on TSM and its effectiveness on safety performance are invited.

In conclusion, the proposed TSM principles highlight a positive safety culture that rejects any unsafe practices, a company-wide practice of leadership and both single loop and double loop learning to improve safety performance, a sense of partnering with suppliers, a working system that allows higher autonomy in all functional units, a confidence in investing in training, and a control system that aims at continual improvement by not pin-pointing responsibility. Such a TSM program should be implemented as a whole - incomplete implementation may trigger a domino effect and result in disappointment.

TSM implementation shall start with a well-designed training program to introduce its ideas to staff members and a culture refining program that changes the value system of staff members: safety is not a burden; it is a value that must be protected. Though extra cost might be incurred, it will pay off in form of overall saving and performance advancement.

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