ASSESSING QUALITY MANAGEMENT RELATIONSHIP IN PUBLIC CONSTRUCTION IN TAIWAN USING FAULT TREE ANALYSIS

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Abstract
ISO 9000 has gained popularity and is being applied to manufacture-related companies all over the world as a system of standards related to quality assurance management and control. Fault Tree Analysis (FTA) is an important risk-evaluating technique and has been used to present the relationships among the elements of the ISO 9001 standard in ISO implementation. However, a review of the literature suggests that it is much more difficult to manage quality in relation to construction industry due to its generic nature.
This paper used FTA to evaluate the relationships among the elements of the ISO 9001:2008 standard and the root causes of defects on public construction quality assessed by Taiwan Public Construction Commission from year 2005 to 2007. Based on the results in this study, ISO 9000 quality management practices may be needed more emphasized in certain stages, the failed probability of check stage was potentially the highest. The implementation of plan stage was also likely to have a significant effect on public construction quality and this showed the importance of the two major elements of the ISO 9001 standard.
Keywords: Public Construction, ISO 9001 Quality Management System, Fault Tree Analysis, Taiwan.

1. INTRODUCTION

It was recognized that quality is one of the discriminating elements for manufacture-related firms to provide quality products that will both satisfy the customer and survive in an ever-competitive market. However, construction professionals are now beginning to realize that it is much more difficult to understand, interpret and manage quality in relation to construction industry. A review of the literature suggests that project characteristics of construction industry have an importance role to play in affecting quality performance (Sidwell, 1983; Chan et al, 2006). How construction differs from manufacturing is characterized that constructed facilities are unique, and seldom mass produced. Besides, the members of construction team (architect, engineer, and contractors) usually change with each project (Ortega and Bisgaard, 2000). Especially in a public construction project, more participants and interest parties are involved hence the public construction quality is always a major subject for governments all over the world. Therefore, the public construction quality needs to be readily assessed, described, analyzed, explained, and generalized.

ISSN
2067- 2462

ISO 9000 series of quality management standards has gained wide acceptance in many industrial sectors including the global construction market since it was first published by the International Organization for Standardization (ISO) in 1987. Numerous studies have been carried out which have applied ISO9000 quality management in construction industry (Pheng et al., 1999; Ng, 2005). Bubshait and Al-Atiq (1999) evaluate against the ISO 9000 standard the quality systems of 15 construction contractors in Saudi Arabia. Chin and Choi (2003) examine the success factors for the implementation of ISO 9000 in the Hong Kong construction industry. Chini and Valdez (2003) attempt to determine the applicability and effectiveness of ISO 9000 in American construction firms and the barriers that hinder its acceptance. Each study has its own contribution to make in respective terms, but the meaning of quality in public construction seems to enclose within its local characteristics of country (Xiao and Proverbs, 2002).

The public construction in Taiwan has experienced difficulties in developing and implementing effective management systems that improve the quality of public construction and it is still recognized by poor quality. ISO9000 series of quality management standards was promoted by Public Construction Commission (PCC) which was established in 1995 to manage and assess the quality of public construction. Therefore, the objective of the present paper was to analyze the feasibility of conducting ISO 9000 quality management system in the public construction by linking the probabilities of poor public construction quality in Taiwan to their relevant ISO 9001:2008 quality management standard factors. We adopted Aghaie's (2004) study which attempts to show the possibility and benefits of using Fault Tree Analysis (FTA) in the area of Total Quality Management (TQM) by presenting and evaluating the relationships among the elements of the ISO 9001:2000 standard and the potential problems and root causes of failure in ISO implementation. Prioritizing the public construction industry's viewpoint on the factors in ISO9000 series of quality management standards by using FTA into a decision support tool will improve the public construction quality in Taiwan.

2. PUBLIC CONSTRUCTION IN TAIWAN

The quality assessment of public construction projects in Taiwan involves two components: quality assurance and quality control as shown in Figure 1. Quality assurance is defined as a "system of controlling the provision of a product or service so as to satisfy the needs of the customer" and it is identified as an external quality system, covering activities aimed at inspiring confidence in the client regarding the product or service being provided (Chini and Valdez, 2003). Quality control is considered to be the "specific implementation of the quality assurance program and related activities" (Arditi and Gunaydin, 1999; Chini and Valdez, 2003).

ISSN
2067- 2462

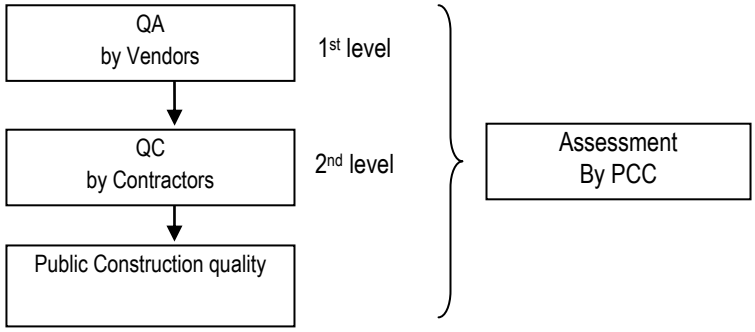

FIGURE 1 - THE ASSESSMENT SCHEME OF PUBLIC CONSTRUCTION PROJECTS IN TAIWAN

TABLE 1 - LIST OF THE ROOT CAUSES OF DEFECTS FROM YEAR 2005 TO 2007

Causes of defects	Corresponding ISO9001:2008 Clauses	Counts	(%)
Monitoring plans not fit for needs	7.2.1. Determination of requirements relating to product	65	8.36
Record format not fit for needs	7.1. Planning of product realization	32	4.12
No tracking records	7.5.3.Identification and traceability	32	4.12
Material sampling test not recording root causes of defects	7.4.2. Purchasing information	27	3.48
Checking records incorrect	8.2.3. Monitoring and measurement of process	25	3.22
Monitoring plans not effectively implemented	8.2.3. Monitoring and measurement process	23	2.96
Quality samplings not effectively conducted	7.4.3. Verification of purchased product	23	2.96
Non-conformance records missing	8.3. Control of non-conforming products	20	2.58
No approvals on monitoring plans	7.2.2. Review of requirements relating to product	10	1.28
No sampling test on receiving materials	7.4.1. Purchasing process	10	1.28
No management review records	5.6. Management review	9	1.14
Management review problems	5.6. Management review	66	8.34
Quality control plans not fit for needs	7.1. Planning of product realization	70	9.00
Checklists incomplete	8.2.4. Monitoring and measurement of product	44	5.66
No warning actions taken on sites	6.4. Work environment	33	4.42
No corrective and preventive actions	8.5. Improvement	32	4.12
No responsibility personnel	6.2. Human resources	29	3.70
No safety protections when operation in high	6.3. Infrastructure	28	3.60
Quality control plans not effectively implemented	7.5.1. Control of product and service provision	28	3.60
Documents and records not well managed	4.2. Documentation requirements	26	3.34
Quality responsibility not defined	5.5.1. Responsibility and authority	21	2.70
Against law No. 35 of Construction Acts	N/A	21	2.70
Quality control process not monitored	7.5.2. Validation of process for product and service provision	15	1.92
No checking records	8.2.4. Monitoring and measurement of product	15	1.92
Material sampling items missing	7.4.3. Verification of purchased product	13	1.68
No control actions of non-conforming materials	8.3. Control of non-conforming product	8	1.02
No protection fences on site	6.3. Infrastructure	18	2.32
Customer focus inadequate	5.2 Customer focus	35	4.46

Total quality management and ISO 9000 quality management system have gained much acceptance in many industrial sectors but public construction is limited in Taiwan. ISO 9000 registration is regarded to provide a stepping stone toward total quality management practices. The assessment in public construction relied on

ISSN
2067- 2462

the philosophies, methods and techniques concerning total quality management and ISO 9000:2008 quality management system that have applied all over the world. PCC determined the public construction industry's viewpoint on the ISO 9000:2008 quality management system which would improve public construction quality in Taiwan. Many participants viewed the achievement of public construction quality as a function of relationships rather than a matter of strict adherence to specification. Therefore, the quality management relationship in public construction is an essential first step toward establishing the ISO 9001:2008 quality management system.

The assessors are made up of the PCC's project team. They evaluate public construction quality performance under yearly review to provide an objective means to assess public construction and safety standards against ISO 9000:2008 quality management system standards for improving contractors' performance. Table 1 shows the assessment results by the classification of the root causes of defects on public construction quality management from year 2005 to 2007 as example. Hundreds of sites were assessed, varying in type of size, structure, contract, and located throughout Taiwan. It provided information for preparing development plan to prevent non-conforming works by vendors and contractors accordingly in purpose.

ISO 9000: 2008 Quality Management System

The ISO 9000 series of quality management system are basically designed for externally certification. It considers the nature of total quality management (TQM) which is customer-driven in the subsequently updated version in 1994, 2000 and 2008. It stresses the involvement of everyone inside an organization and the relationships with suppliers. It addresses the aspect of quality as a consistency in the production of a product or service. It requires top management commitment, leadership, training and education. The new version of ISO 9000:2008 for certification or for contractual purposes also asserts the role of the well-known standards as a plan-do-check-action (P-D-C-A) model of TQM for continual improvement. The major elements of the P-D-C-A model (as shown in Figure 2) includes Clause 4 of Quality-management system; Clause 5 of Management responsibility; Clause 6 of Resource management; Clause 7 of Product Realization and Clause 8 of Measurement, analysis, and improvement (ISO, 2008). Most important, the PDCA model implies the correlation in between the clauses. The quality system is set up, implemented and maintained in compliance with the standards by documentary evidence explaining objectives or goals the organization intends to achieve. In Clause 4, 5 and 6, planning is concerned and carried out through programmes of the necessary means and resources which are supported by top management. Clause 7 represents the implementation stage and Clause 8 is an important aspect that is provided for the purpose of checking whether the firm activities and quality system comply with what has been planned, then reporting the results to the top management.

ISSN
2067- 2462

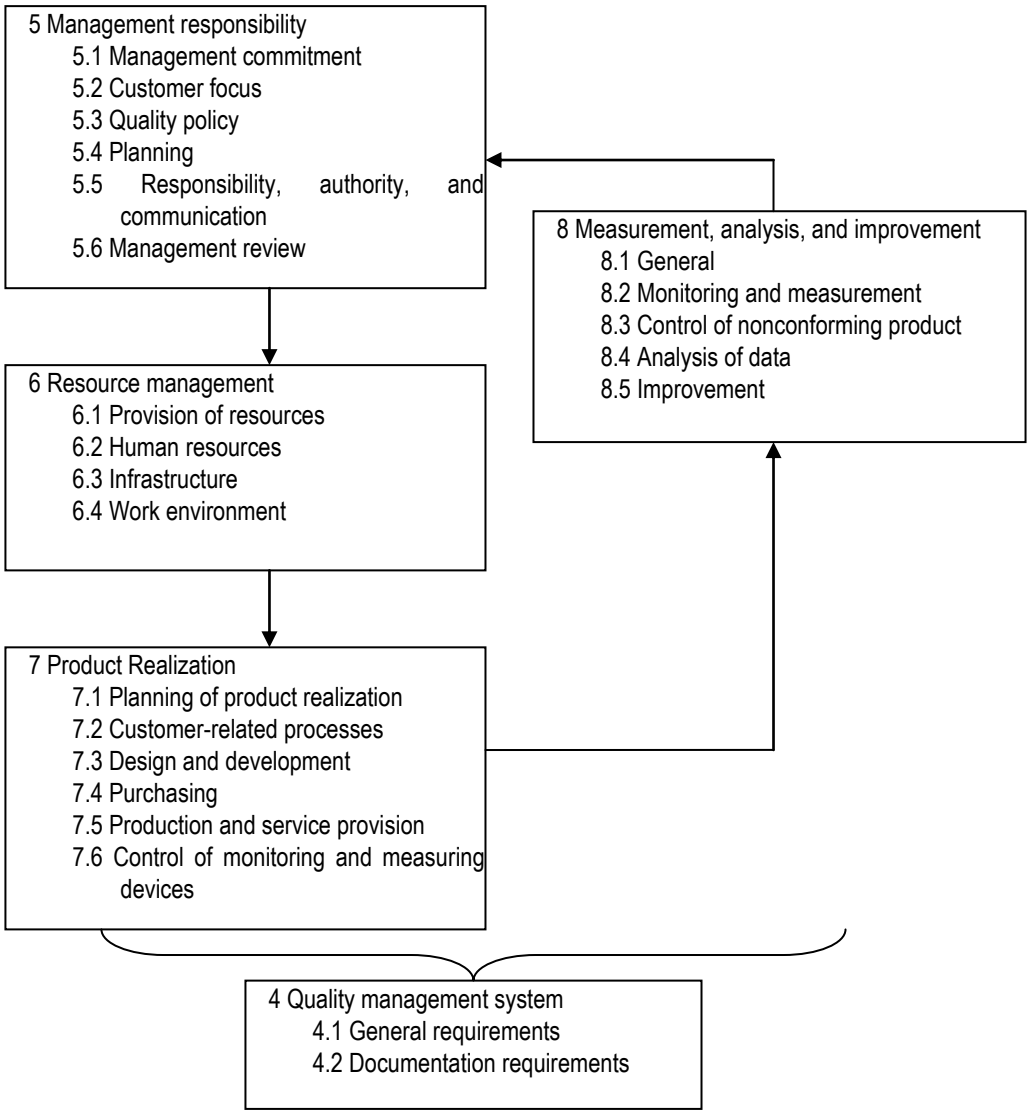

FIGURE 2 - THE P-D-C-A MODEL OF ISO 9000 SERIES OF QUALITY MANAGEMENT SYSTEM

Analysis of the ISO-FTA Model

According to Aghaie's (2004) study, the ISO-FTA model can be developed by drawing the best possible relationships among the elements and requirements of the ISO standard. Moreover, we integrated the ISO-FTA model by correlating all the clauses in the PDCA model by experts' opinion. Therefore, the hierarchy of the ISO-FTA model is developed and exactly based on the levels and relationships existing among clauses and sub-clauses of the ISO9000 standard (as shown in Figure 3, 4,5 and 6) in four stages of PDCA model.

The ISO 9000:2008 clauses most complied with is management responsibility and the attempt to implement ISO 9000 quality management system within the public construction has given rise to resistance from the other stages. Top management commitment on company-wide goal can initiate an empower culture to have effective team-working on continuous improvement, However, it may not be good enough to generate better

ISSN
2067- 2462

company performance on public construction quality. It was possible that the difference in failed stages for this study might be explained mainly by industry feature of public construction in Taiwan.

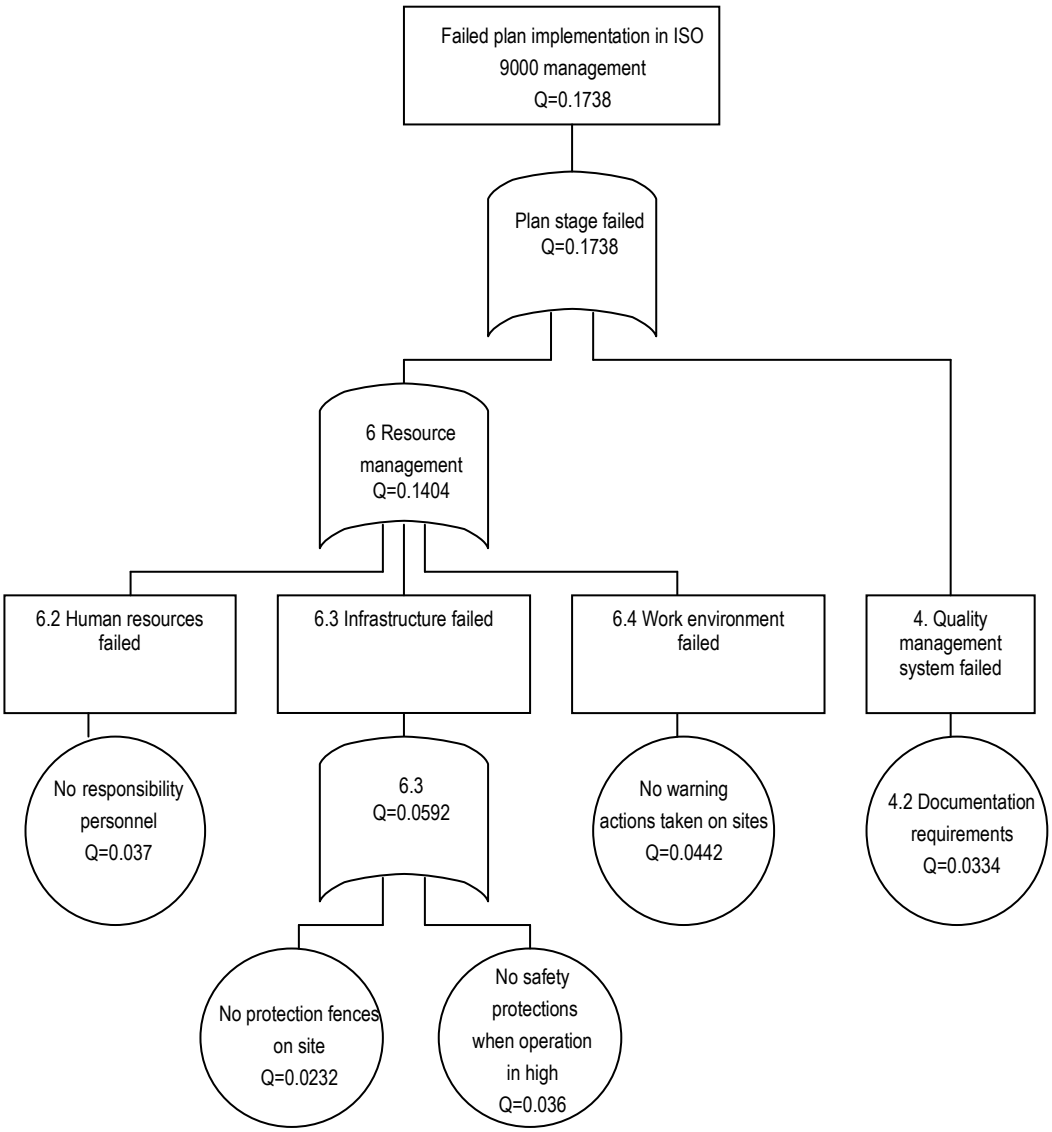

FIGURE 3 - TREE OF FAILED PLAN IMPLEMENTATION IN ISO 9000 MANAGEMENT

To investigate the reasons for the levels of quality management relationship in public construction, informal interviews were conducted with foremen, engineers, managers and auditors about the above analysis. There was a general consensus amongst respondents that certain elements or stages of ISO 9000 quality management practices on public construction quality may be needed more emphasized. Some comments were summarized as follows.

The amount of documentation involved in ISO 9000 Quality Management System seems to be exorbitant. It is felt that certain categories of people have existed to make business and money by propagating more ISO 9001 certifications. Despite the fact that all contractors involved in public construction had quality management system in operation, the quality achieved generally fell below the required standards.

ISSN
2067- 2462

Furthermore, the field study has revealed a tendency for practitioners to reject the ISO 9001 certification in construction industry. It is not to suggest that a systematic approach to public construction activities along the lines of ISO 9001 standards is of no value to the construction quality. However, little studies were conducted to justify the ISO 9000 quality management relationship in public construction.

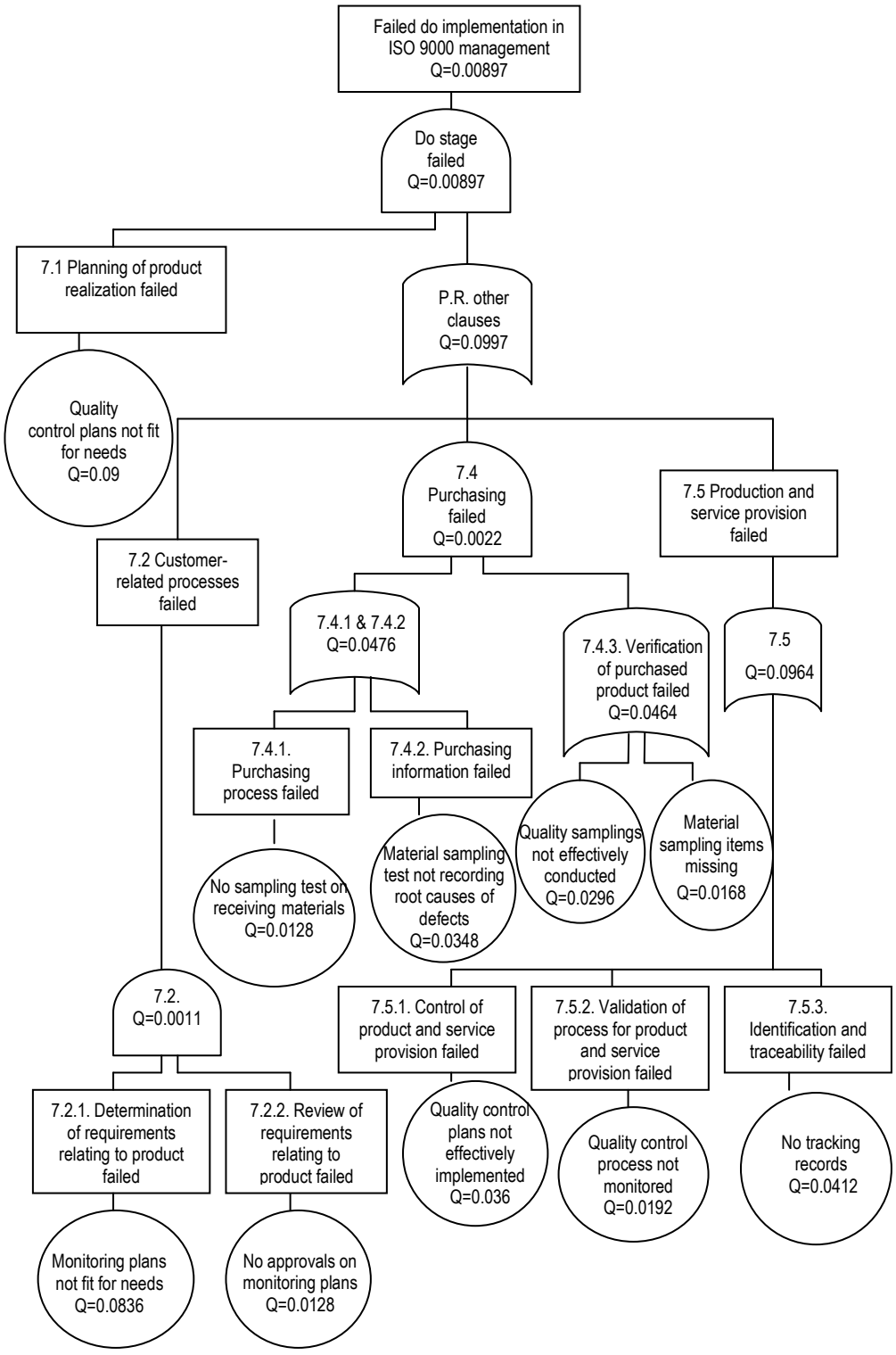

FIGURE 4 - TREE OF FAILED DO IMPLEMENTATION IN ISO 9000 MANAGEMENT

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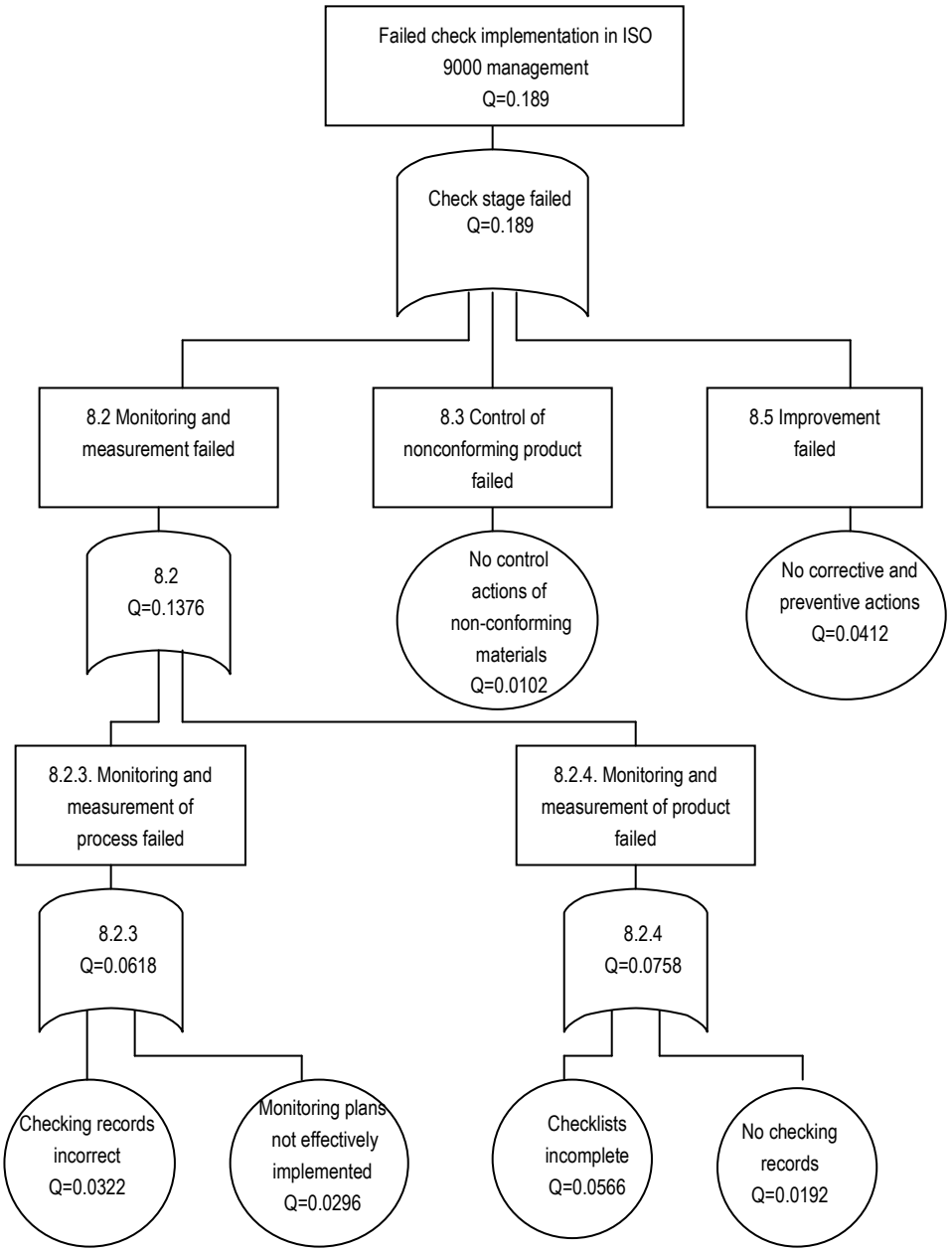

FIGURE 5 - TREE OF FAILED CHECK IMPLEMENTATION IN ISO 9000 MANAGEMENT

The members of construction team (vendor, architect, engineer, and contractors) usually change with each project. Neither the architects nor the engineering designers consider the necessary constructional feasibility of their projects due to the lack of integration they have with the contractors performing the actual task of construction (Serpell et al., 2002). Quality management system in plan stage should flow from one source, namely the contractor. The receipt of instructions from two sources may result in confusion. It is better if the contractor is given the reinforcement detailing responsibility. Besides, it is believed that better quality regulations regarding defects in the quality of public construction projects is a strong drive for quality awareness within construction companies. It provides vendors with more inspection power to get better responses in the face of quality problems during quality system realization.

ISSN
2067- 2462

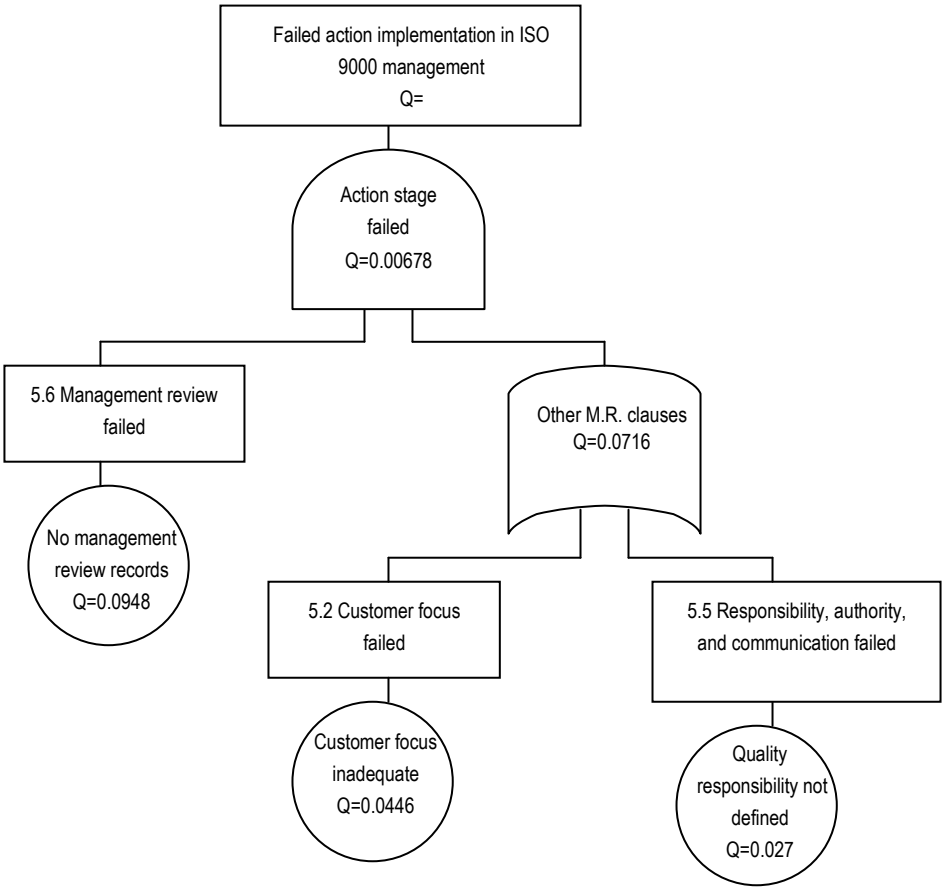

FIGURE 6 - TREE OF FAILED ACTION IMPLEMENTATION IN ISO 9000 MANAGEMENT

3. CONCLUSIONS

The quality management tasks of a general contractor in the public construction industry are important. The public construction quality needs to be readily assessed and ISO 9000 quality management system shed light on some of these assessment issues that underpin a TQM system in public construction. However, there are marked differences in interpretation of ISO standards by the authors and extensive modifications become necessary to Quality Management System documentation after every audit (Acharya and Ray, 2000). Therefore, we analyzed the feasibility of conducting ISO 9000 quality management system in the public construction by linking the probabilities data of poor public construction quality in Taiwan to their relevant ISO 9001:2008 quality management standard factors.

Aghaie's (2004) study attempted to show the possibility of using FTA to present the relationships among the elements of the ISO 9001:2000 standard in ISO implementation. Furthermore, this work adopted it in the area of public construction quality by using the root causes of defects assessed by Taiwan Public Construction Commission from year 2005 to 2007. Evaluating the hazards and most critical events which may result in unsuccessful implementation of the ISO 9001:2008 standard by using FTA into a decision support tool will improve the public construction quality in Taiwan.

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2067- 2462

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2067- 2462